This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

THE LIBRARY OF CONGRESS
1800

Class HE393
Book A13
1910

2

LAKES-TO-THE-GULF DEEP WATERWAY

STATEMENT OF

MR. LYMAN E. COOLEY, C. E.

428
947

JANUARY 28, 1910

BEFORE THE u.s. COMMITTEE ON RIVERS AND HARBORS OF THE
HOUSE OF REPRESENTATIVES OF THE UNITED STATES

SIXTY-FIRST CONGRESS, SECOND SESSION

CONSISTING OF

D. S. ALEXANDER, N. Y., CHAIRMAN.
GEORGE P. LAWRENCE, MASS.
JAMES H. DAVIDSON, WIS.
JAMES McLACHLAN, CAL.
H. OLIN YOUNG, MICH.
HARRY C. WOODYARD, W. VA.
WILLIAM A. RODENBERG, ILL.
WILLIAM E. HUMPHREY, WASH.
MARTIN B. MADDEN, ILL.
CHARLES A. KENNEDY, IOWA.
JAMES H. CASSIDY, OHIO.
JOHN K. TENER, PA.
STEPHEN M. SPARKMAN, FLA.
JOSEPH E. RANSDELL, LA.
GEORGE F. BURGESS, TEX.
BENJAMIN G. HUMPHREYS, MISS.
JOHN A. MOON, TENN.
GEORGE W. TAYLOR, ALA.
J. EDWIN ELLERBE, S. C.
CHARLES G. EDWARDS, GA.
FRANK D. FLETCHER, CLERK.
JOSEPH H. McGANN, ASSISTANT CLERK.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1910

D. OF D.
MAY 15 1912

HE393
A13
1910

LAKES-TO-THE-GULF DEEP WATERWAY.

COMMITTEE ON RIVERS AND HARBORS,
HOUSE OF REPRESENTATIVES,
Friday, January 28, 1910.

The committee met at 10.30 o'clock, a. m., Hon. De Alva S. Alexander (chairman) presiding.

The CHAIRMAN. We will be very glad to hear you now, Mr. Cooley. Take your own time in addressing the committee. Mr. Cooley needs no introduction to the members of this committee who heard him for an hour or more early in the session with a great deal of pleasure.

STATEMENT OF MR. LYMAN E. COOLEY.

Mr. COOLEY. Mr. Chairman and gentlemen, I received a report on the subject of the Lakes and Gulf waterway on December 8, I believe, and the atlas and the other documents in connection with the report on December 15. Since then I have been engaged in preparing a number of exhibits to illustrate certain special features of the Lakes and Gulf waterway, and I anticipated having more time than has been given me. I have the essential facts in my mind, but they are scattered around as in a construction yard, and have not been assembled, and so the course of my remarks may be somewhat desultory. I wish first, however, to call attention to two or three of these exhibits which are general, and later to take up two or three special exhibits which bear upon matters which I understand are uppermost in the minds of the committee and devote my attention particularly to that part of the route between Chicago and Cairo. I understand that the mind of the committee is substantially settled on the questions below Cairo.

The first three exhibits were intended to illustrate certain broad features of the topography of the United States. The first exhibit is not completed and is not here; that was a map of North America extending from the Gulf of Mexico, or rather from the Isthmus of Panama, up to the northern limit shown on the Canadian map where potatoes and wheat and barley ripen.

The CHAIRMAN. Before you proceed, I will say that we have a stenographer here who is taking down the hearing, and you will be given the opportunity of revision just as if you wrote it out in the beginning.

Mr. COOLEY. Thank you, sir.

The CHAIRMAN. And also you may make any additions you desire to make, putting in any details and statistics that you may desire.

Mr. HUMPHREYS. Mr. Cooley stated just now that he would not be able to go as fully into the matter as he had hoped to, because his time was limited.

Mr. MADDEN. There is no limit to the time for this hearing. Mr. Cooley meant that his time for preparation had been limited.

The CHAIRMAN. No, there is no limit to the time here; he has all the time there is.

Mr. COOLEY. It was designed to show upon this map of North America (Exhibit No. 1) the 1,000 and 2,000 foot horizons above sea level, and the arable areas and semiarid regions, and also the routes for the Lakes and Gulf waterway which we have under consideration; the route for the waterway which was examined some years ago by the board of engineers through the Lakes to the Atlantic and the possible route up into the Canadian Northwest, eventually reaching Hudson Bay by way of Lake Winnipeg and Nelson River, and to develop the fact that we have within the limits of the two mountain chains and between the Gulf and the northern limit of food production, an area equivalent to 2,000,000 square miles measured in standard humid territory, or ten times the area of either France or Germany, and capable of carrying, on the basis of France 400,000,000 people, on the basis of Germany 600,000,000 people, on the basis of parts of China and India more than a billion people, or all the population now on the earth.

The CHAIRMAN. That is between the Alleghenies and the Rockies?

Mr. COOLEY. Yes, sir; and between the barley and potato limit and the Gulf of Mexico.

Mr. MADDEN. If I do not interrupt you too much, I would like to ask what portion of that is north of the United States boundary?

Mr. COOLEY. About 30 per cent north, and about 70 per cent south.

Mr. TAYLOR. By that you mean that 30 per cent is up in Canada?

Mr. COOLEY. Yes, sir. The relative food-producing area in Canada is about three-sevenths, or over 40 per cent of that of the United States. Between the two ranges of mountains, in what we call the Greater Mississippi Valley, is comprehended about two-thirds of the resources of the continent, north of Mexico. The map is also designed to show the route down to the Panama Canal, through the American Mediterranean, the Gulf of Mexico, and the Caribbean Sea, and the Great Lakes connected thereto as by a strait. There is to go with that map a profile (Exhibit No. 3) now in preparation, extending from the Gulf of Mexico to the Gulf of St. Lawrence, 3,300 miles, showing a midway summit of only 580 feet above sea level, which is the level of Lake Michigan.

Mr. TAYLOR. Where is that midway summit?

Mr. COOLEY. At Chicago, 1,600 miles, in round numbers, from the Gulf of Mexico, and 1,700 miles from the Gulf of St. Lawrence. Chicago is midway, with an altitude of 580 feet; that is the altitude of the low water of Lake Michigan.

Mr. TAYLOR. Where is the highest altitude along that?

Mr. COOLEY. About 11 feet above Lake Michigan and immediately west of the city limits of Chicago.

Mr. TAYLOR. I mean the highest altitude from that to the Gulf of St. Lawrence?

Mr. COOLEY. It is at Chicago.

Mr. TAYLOR. It is at Chicago?

Mr. COOLEY. Yes; and that altitude is less than the absolute elevation of the top of the Washington Monument opposite the White

House. A waterway along this route from the Gulf of St. Lawrence to the Gulf of Mexico 24 feet deep can be produced for the probable cost of the Panama Canal. There is also in preparation a profile branching from the same route at the Great Bend of the Illinois at Hennepin, by way of the upper Mississippi and Minnesota rivers and Red River of the North, to Hudson Bay, and along that line it would reach an altitude between Minnesota and the Dakotas of about 950 feet above sea level, beyond which you are on the down grade in the Canadian Northwest, in the wheat region, this side of and around Lake Winnipeg.

(Mr. Cooley here unrolled upon the committee table a map.)

This exhibit (No. 2) simply developes the relief of the United States. We have here in blue color all the territory of the United States under an elevation of 500 feet, and most of that territory within the Mississippi Valley. This limit of 500 feet comes within 40 miles of Lake Michigan at Chicago, where it is 80 feet higher. There is also a pass across the State of New York which is under 500 feet. So the only two low-grade outlets for large water routes within the limits of the United States lie up this pass at Chicago and across through the Mohawk Valley, in the State of New York.

The next color is the 500 to 1,000 foot area; and you will see there the pass which I spoke of, leading to the Canadian northland by the Red River of the North. That is the only gap within the limits of the United States of less than 1,000 feet going north. Within this limit of 1,000 feet are comprehended practically all the waterway possibilities in this country. If this map showed the 750-foot horizon, you would find that the Ohio River clear to Pittsburg and the Mississippi River clear to St. Paul, and the Missouri River to Kansas City, and the Tennessee River to a point between Chattanooga and Knoxville, and the Arkansas River to Fort Gibson, and the Red River way up to a point opposite Dallas, Tex., all lie within the limits of 750 feet. In fact, the elevation of the Ohio River at Pittsburg, and of the Mississippi River at St. Paul, and of the Tennessee River between Chattanooga and Knoxville, and of the Missouri River at Kansas City, all lie within a limit of less than 20 feet of each other from an elevation of 700 feet. The contour horizon 750 feet above sea level will develop all the great possibilities of the country. The only river which really breaks beyond the 1,000-foot contour is the Missouri, and that goes beyond the 2,000-foot contour clear to Fort Benton at the foothills of the Rocky Mountains, where it has an elevation of 2,565 feet.

The CHAIRMAN. That part colored brown is the 1,000-foot part?

Mr. COOLEY. This color in here [indicating on map] is between 500 feet and 1,000 feet. This intermediate color is from 1,000 to 2,000 feet. This color [indicating] is from 2,000 to 5,000 feet. You see a limited section in here of the Allegheny or Appalachian region [indicating], lying above 1,000 feet and reaching at a few points only above the 2,000 feet. But when you go west from the margin of the 2,000-foot contour, you rapidly rise in elevation, and you have a large area there of 5,000 feet and a limited area reaching 10,000 feet, shown here in very dark color. The arid line, which is usually taken at the one hundredth meridian, virtually skirts the 2,000 feet of elevation in the United States. Everything east of 2,000 feet is socalled humid territory. There is an area of about 1,000,000 square miles lying west of this arid line, between meridians 99 and 100, and extending to the Pacific sea, which is incapable of cultivation except in limited tracts without the aid of irrigation, and of this area it is estimated that 75,000 square miles can be actually irrigated. The remainder has a moderate value for pasturage and forestry, although the forests in that region do not compare with humid forests.

I have delineated on this map the route of the Lakes and Gulf waterway between the Gulf of Mexico and Chicago, and also the route down through the Lakes and the St. Lawrence, upon which the profile mentioned is based. There are also shown on the map some characteristic elevations at the terminal points on the Ohio, the Mississippi, the Missouri, and the Tennessee, to which waterways of magnitude may reach, or, as I have stated, all under elevation 750 feet above sea level. You will find also the elevations of the Lakes—580 feet for the water of Lake Michigan at Chicago, Lake Superior 20 feet above that, and Lake Erie about 8 feet below it—and also the elevation of Cairo, which is a little less than half the altitude of Lake Michigan.

(Mr. Cooley here exhibited another map to the committee.)

This exhibit (No. 4), on a scale of 5 feet to the inch, is a map from Chicago to the Gulf of Mexico, designed particularly to develop the general course of the route and the area and extent of the alluvial lands. This map is not exactly official, but was made under my direction from official charts and other data by the draftsmen in the office of the Mississippi River Commission working overtime on my personal account, but a special plate was made to extend the map over the upper Illinois River to Lake Michigan at Chicago.

The area of the alluvial lands in different subdivisions is given in the table on the map. About 95 per cent of these lie below Cairo. The aggregate area of overflowed lands—that is, lands subject to overflow—is 31,221 miles, or approximately 20,000,000 acres. One thousand four hundred and thirty-one miles of this area lie above Cairo, 740 miles on the middle Mississippi from Cairo to Grafton, and 691 miles on the Illinois River from Grafton to Joliet. The remainder lies below Cairo. This 20,000,000 acres, in my humble judgment, together with the alluvium adjacent which is not subject to overflow—you see patches of it through the blue color and beyond—has more intrinsic value than all the lands that will ever be reclaimed by irrigation from the arid region, which are estimated at something like 50,000,000 acres.

The CHAIRMAN. Did I understand you to speak of lands under irrigation?

Mr. COOLEY. Yes, sir. I say, in my judgment, this land has more intrinsic value than all the lands that will be reclaimed by irrigation.

Mr. TAYLOR. Which lands constitute, you say, about 50,000,000 acres?

Mr. COOLEY. About 50,000,000 acres, as compared with 20,000,000 acres plus an additional alluvium, which is not estimated here but which will make a total of perhaps 30,000,000 acres, There is only painted on this map the area that is subject to actual overflow, within the limits of the water. In the best days of Egypt, on the best estimates that have been made, there were 5,000,000 acres under cultivation, and it carried a population of about 10,000,000 or about two people to the acre; so, on a similar basis of ultimate population this alluvial region would carry a population of 40,000,000 of itself.

Mr. Madden. This alluvial region which is now subject to overflow?

Mr. Cooley. Yes, sir.

Mr. Cassidy. It does carry some people now, does it not?

Mr. Cooley. Yes; they have spent large sums of money below Cairo. The United States, together with the six States known as the "levee States," have spent over $95,000,000.

Mr. Rodenberg. What is the present population of this alluvial region you refer to?

Mr. Cooley. It is nominal. I would not undertake to make an estimate of it, but it is not very large.

Mr. Taylor. This alluvial land you speak of constitutes that which is subject to overflow regularly?

Mr. Cooley. No, sir; only in high-water seasons. Some of it is overflowed every year. It contains all the washings of the continent. It is the cream jug, you might say, produced by the degradation of the mountain slopes.

Mr. Taylor. It raises crops now every year, does it not?

Mr. Cooley. Since it has been protected by levees, they are gradually reclaiming it for culture. Before that time it was a hazardous proposition.

Mr. Humphreys. All of it is susceptible of reclamation by drainage?

Mr. Cooley. Yes; four times the area of Egypt. In the days of Ismael Pasha the cultivated area of Egypt was about 2,500,000 acres, or about one-eighth of the area between Chicago and the Gulf of this alluvial land, and to-day it is being brought up again under the patronage of the British Government. I do not know that there is anything further to say in regard to this map. It tells its own story.

I will ask you now to look at this profile (Exhibit No. 5) [exhibiting same]. This is a profile from Chicago to Cairo, 539 miles, showing the river and the depths of water as they now exist.

Mr. Madden. How many miles did you say?

Mr. Cooley. Five hundred and thirty-nine miles.

The Chairman. From the end where you stand, that is the Chicago end, it is 539 miles? Here is Cairo at this end.

Mr. Cooley. Yes, sir. Each of those checks horizontally represents a mile, and the scale of distances is given along the margin from the mouth of the Chicago River at Lake Michigan. Each of the vertical checks represents ten feet; and knowing this scale, you can pick out the elevation of any point and the depth of water. These are all the data that exist upon the subject of the water trail or channel between Chicago and Cairo, except the rock borings which we did not have time to put on, underneath. Perhaps this is more particularly an engineer's profile than it is one for general use. At the same time, it gives comprehensively the distances and declivities and depths as they now exist in different reaches of the route. On this end is the Chicago drainage canal, including the Chicago River, extending for 36 miles from Lake Michigan, with a depth of 24 feet. The next 61 miles covers the rock-bound section of the Illinois Valley, where all the steep declivities are concentrated, having a total fall of 146 feet from the level of Lake Michigan. That section is the section covered by the constitutional amendment of the State of Illinois which authorizes the legislature to expend the sum of $20,000,000 thereon.

The next section is from Utica through the alluvial valley to Grafton, a distance of 230 miles, where the declivity is only 28 feet, less than an inch and a half to the mile. That declivity is remarkable among American rivers.

Mr. MADDEN. That is the Illinois River, is it not?

Mr. COOLEY. Yes, sir; that is the Illinois River. That is a relic of the ancient outlet of the Lakes which carved the valley on that low grade.

Mr. MADDEN. What did you say was the length of that first section?

Mr. COOLEY. Sixty-one miles from Lockport to Utica. The section between Utica and Grafton requires a deep channel not only to carry the water which we are putting into the river from Lake Michigan, but a permanent improvement requires depth in order to give velocity to the water to enable it to clear the channel; and as I said before the committee on a former occasion, you could not, from an engineering standpoint, do with less than 14 feet through that division if you wished to, without incurring trouble and expense in the future in maintaining the channel.

Mr. MADDEN. Will the lowering of the bed of the Illinois River tend to prevent overflow of the adjacent land?

Mr. COOLEY. Yes, sir.

Mr. TAYLOR. I did not catch that.

Mr. COOLEY. I say it will tend to prevent overflow of the adjacent lands.

The CHAIRMAN. Lowering it how much?

Mr. COOLEY. According to the state programme we propose to lower the bed of the Illinois River so that it will carry 14,000 feet of water from Lake Michigan, below the natural low-water level of the stream. It will have some greater capacity under that condition for carrying floods than now; it will be a better drain.

The CHAIRMAN. Before you get through will you give the gentlemen of the committee some idea about the volume, so many thousand cubic feet per second at high water, going down the Illinois, and the number of cubic feet per second at low water?

Mr. COOLEY. I will do that. This blue color on this map represents that low-water condition. There are lines on here which represent other stages of water (indicating), as the bank-full stage, which is the most important stage, or point at which the river begins to overflow; and there are also other flood stages represented, as the extreme high water; and on those lines you will find, if you inspect the profile closely, the volume given in second-feet for each characteristic stage, so that all of that is a matter of record on the profile.

The section from Grafton to Cairo has a declivity of about 132 feet in a distance of 212 miles, or about 7½ inches to the mile—more than five times that of the Illinois River—and as I stated in my former talk before the committee, that steep declivity accounts for the bad conditions in the middle Mississippi.

The CHAIRMAN. What you call the middle Mississippi is from the Missouri down to the Ohio?

Mr. Cooley. From Grafton to Cairo; from the mouth of the Illinois to the mouth of the Ohio, 212 miles, with a total fall of 132 feet.

The Chairman. It is about 198 miles from St. Louis to Cairo.

Mr. Cooley. One hundred and seventy-five miles by the mid-bank distance and 37 miles from St. Louis up to the mouth of the Illinois, which makes the 212 miles. At Cairo you are at a level 306 feet below the level of Lake Michigan and 274 feet above the Gulf. In other words, the Cairo elevation at low water is less than half that at Chicago, and mid-stage at Cairo, 16 feet above low water, would be exactly at half the elevation of Lake Michigan. This profile also comprehends about one-third of the total distance, some 1,604 miles, to the Gulf, and 539 miles is covered between Chicago and Cairo.

I have two other exhibits here (Nos. 6 and 7) which are designed to illustrate particularly the upper Illinois section covered by the state constitutional amendment (exhibiting map).

Before I take that up, however, I wish to answer as to a point or two of the chairman in regard to the volumes of water in the Illinois River and in the Mississippi River. The volume flowing at St. Louis at low water, which I have taken for certain estimates which I will speak of later, is 41,000 cubic feet of water per second. The river does not fall below that volume for an average of over one and two-tenths days per year, or forty-eight days in a total of forty years, of which period we have the records. The volume that flows in the river for eight months of the year is 106,000 feet. The volume that flows at bank-full stage, or 30 feet above low water on the St. Louis gauge, is 606,000 second-feet—606,000 cubic feet per second. The river, on the average, is above the bank-full stage at St. Louis for two days per year, or a total of eighty days in forty years. There have been extreme floods, such as occur twice in a century, perhaps, like that of 1903, which rose to 950,000 feet.

Mr. Madden. A second?

Mr. Cooley. Yes; and in the high water of 1844, which is the record high water on all the western rivers—that is, below Omaha—the river reached an estimated volume of 1,360,000 feet at St. Louis. There are no absolute data as to that, but it is a "guesstimate" rather than an estimate.

Mr. Madden. When it was running at that quantity per second what would be the rapidity of the flow?

Mr. Cooley. When you get above the 30-foot stage you are out over the bank. That was 11.3 feet above the bank-full line at St. Louis at that time, and the valley was a lake, and the whole valley was carrying water from there down to Cairo.

The Chairman. And at what velocity, Mr. Madden asks?

Mr. Cooley. At the bank-full stage the general velocity of the Mississippi River from St. Louis to Cairo would be about 4 miles per hour. It might be increased somewhat in the channel at these higher stages, but not greatly. When a river reaches bank-full and begins to overflow there seems to be such a confusion produced, in comparison with the regular flow within banks, that the river itself does not really run faster; it runs more irregularly.

Mr. Cassidy. What is the speed of the current at low water?

Mr. Cooley. In the pools it is nominal. On the bars, from a great many examinations that I made of the Missouri River, I found that the bars began habitually to cut out when it got above 3 feet per second.

The CHAIRMAN. Can you credit a report that comes to us from the flood in the Seine, that it is running 30 miles an hour?

Mr. COOLEY. No, sir; it is not true. The highest velocity I ever measured was in the Missouri River, at Nebraska City, produced by a sand bar moving against the bluff, and I measured the actual current at 12 miles an hour. It did not last; in a couple of days it cut itself loose. Eight or 9 miles an hour in the pipe of a hydraulic dredge will carry along stones as big as your head.

Mr. CASSIDY. Do you intend later to address yourself to the matter of the flow from Lake Michigan, the necessity for the 14,000 feet, and so forth?

Mr. COOLEY. Yes, sir. Now, coming back to the matter of the volumes in the Illinois River about which the chairman asked a question, the low-water volume at La Salle, which is at the head of the alluvial section of the Illinois, has been as low as in 1867, which is our standard low water, or 633 feet per second, and down below the Sangamon it is estimated at 1,300 feet per second.

Mr. CASSIDY. When it was 600 feet at La Salle, what would it be at the mouth of the Illinois?

Mr. COOLEY. About 1,300, and in the Mississippi below about 22,000, and in the Missouri about 19,000, the two making 41,000, which I gave as the proper measure of low water at St. Louis. The Illinois River is a remnant of an ancient stream. There are parts of this ancient stream, like Lake Peoria, which still exists and has not been fully silted up, just as Lake Pepin exists on the upper Mississippi, the remains of an ancient stream which drained all the Canadian northlands by way of the pass at the head of the Minnesota River, which I alluded to in speaking to the topographical map of the United States; and there are other indications and remnants, like the deeps above Havana, in the Illinois River. But what is left of the ancient stream is simply what has not been encroached upon by spoils from the land, and with the tillage of the land that encroachment is getting worse year by year, and it has not been helped any by the construction of four dams on an extremely low-grade stream, and the evidence of the deterioration of the channel has been very pronounced.

Mr. CASSIDY. You speak of the dams in the Illinois River?

Mr. COOLEY. Yes; two built by the State and two by the United States. The capacity of this stream, therefore, at bank-full stage from La Salle down to the mouth of the Sangamon, nearly two-thirds of the length of that stream, is only 18,000 to 20,000 cubic feet per second before it begins to overflow its banks. Down below the Sangamon it rises to 30,000 and down near the mouth it rises to about 40,000 cubic feet per second. The flood volume at La Salle is about 95,000 to 100,000 cubic feet per second, and near the mouth it ranges from 110,000 to 130,000 feet per second. I believe that covers the question of the chairman.

This profile (Exhibit No. 7) [indicating another profile] is of the upper Illinois River, including the Desplaines River, extending from the end of the Chicago Sanitary and Ship Canal at Lockport, which is shown here, down to La Salle. The provision in the constitutional amendment covers the stream from the end of the Sanitary Canal for this distance of 61 miles down to Utica Bridge.

The CHAIRMAN. Mr. Cooley, the Ernst Board in 1905 provided for 9 locks and 5 dams from Lockport down to Utica. Have you indicated those on your map?

Mr. COOLEY. No, sir; I have not had time to delineate particularly the projects of the Ernst Board.

The CHAIRMAN. This represents particularly the 5 locks and 4 dams?

Mr. COOLEY. Yes, sir. In the blue it simply represents the natural river, and the improvements as they now exist.

The CHAIRMAN. Yes.

Mr. COOLEY. In the red color I have indicated the bases of the state project, which are 5 locks and 4 dams.

Mr. CASSIDY. Would the state project take care of that stretch of the river without any further work on the part of the General Government?

Mr. COOLEY. I was going to speak to that in a little more detail. The fall from Lake Michigan to the proposed level shown by the upper red line there at Utica is 146 feet, and the distance, as before stated, is 61 miles. Of this total fall, 40 feet is at the terminus of the Sanitary Canal at Lockport, and it has been developed partially for water-power purposes by the Sanitary district.

The CHAIRMAN. Indicate where that is on the map.

Mr. COOLEY. Here is the point [indicating on map]. At that point will be a lock from the Sanitary Canal of a lift of 40 feet, locking down into the Joilet level, which is 40 feet below the level of Lake Michigan. The Joilet level continues for a distance of between 5 and 6 miles.

The CHAIRMAN. Just trace with your hand, there, where that Joilet level is.

Mr. COOLEY. Down to that point [indicating], near Brandons Bridge, below Joilet. I might say that this profile is on a scale of 2.5 feet to an inch horizontal, and 5 feet to the inch vertical.

The CHAIRMAN. The length of that Joilet stretch is what?

Mr. COOLEY. 5.24 miles. The lock may be located up or down stream according as final borings may indicate the best point, within limits of half a mile. It is proposed to construct that level 400 feet wide and 24 feet deep at the outset, all of the work being substantially in rock or between masonry walls over that distance.

The next level is the Kanakee level, 35 feet below the Joilet level. There, starting from the head of Lake Joilet and extending down 17 miles (16.66), the red lines indicate its limits, down to the Aux Sable River. There will be a drop of 20 feet down to the Morris level, the next level below.

Mr. MADDEN. The drop at Lockport would be 42 feet, would it not?

Mr. COOLEY. Forty feet as fixed in this plan. It is 42 feet to the pool level as it now exists. The Morris level is 28 miles (27.84), extending beyond the city of Marseilles to the vicinity of Ottawa.

The CHAIRMAN. What depth do you have in the Kankakee level in that length of 17 miles?

Mr. COOLEY. The line is drawn for 14 feet everywhere below the Joliet level. There are also lines drawn there and estimates have been made for 24 feet below Joliet, the same as proposed for the Joliet level, this being the depth in the Sanitary Canal.

Mr. MADDEN. That is 16 miles?

Mr. COOLEY. Yes.

Mr. MADDEN. The Kankakee level is about 17 miles?

Mr. COOLEY. Yes; 16.66.

Mr. MADDEN. And the Ottawa or Marseilles level is 27 miles?

Mr. COOLEY. Yes; 27.84 miles.

The CHAIRMAN. As I understand, the blue on this profile represents water, the natural water in the Des Plaines River?

Mr. COOLEY. Yes; the water as it is to-day, and this represents the river bed as it now exists. Of these red lines the upper one represents the proposed surface of the water and the lower one the depth of 14 feet, and the ground which is to be excavated in the river bed is painted in red, so that you can see the amount of excavation involved. The Ottawa level extends from a point above Ottawa about 10 (10.04) miles to Starved Rock, about a mile above the Utica Bridge (1.44).

The CHAIRMAN. About what is the drop to the Ottawa level?

Mr. COOLEY. Twenty feet. There is practically no excavation involved in that level, and at Utica Bridge, or a mile above Utica Bridge, the final drop is made of 31 feet.

The CHAIRMAN. Where is the Utica Bridge?

Mr. COOLEY. The Utica Bridge is right at the terminus of the upper red line, a mile or so below the last drop and 61.2 miles from the end of the canal at Lockport. That will make a 31-foot drop at that point. The total, as I have stated, from Lake Michigan to the water level proposed at Utica Bridge is 146 feet, 40 feet of this pertaining to the Sanitary District of Chicago and 106 feet from the end of the Sanitary Canal to Utica being covered by the amendment to the state constitution.

Mr. YOUNG. Do you expect to make that 40-foot drop with one lock?

Mr. COOLEY. Yes, sir.

Mr. DAVIDSON. What did you say is the length of this last level?

Mr. COOLEY. About 10 miles. Now, I want to call your attention to a map which ought to be studied in connection with the profile, on a scale of 1 inch to the mile [exhibiting map], showing the valley from Lockport down to Hennepin. This is also where the Hennepin Canal starts out over the hill.

The CHAIRMAN. This stops where?

Mr. COOLEY. At the Illinois River.

The CHAIRMAN. This takes down to Utica and then to La Salle?

Mr. COOLEY. Yes.

The CHAIRMAN. This is La Salle here [indicating]?

Mr. COOLEY. Yes.

The CHAIRMAN. And this is where it goes into the Illinois River indicating]?

Mr. COOLEY. No, sir; it is in the bed of the Desplaines River and the Illinois River all the way. It is not a canal at all, from the end of the Sanitary Canal down to Utica.

The CHAIRMAN. The Desplaines River and the Illinois River come in where?

Mr. Madden. They come together at La Salle, and run right in at La Salle.

Mr. Cooley. The Desplaines River, about 15 miles from Joliet or about 18 miles from the beginning of this profile below the Sanitary Canal, joins with the Kankakee.

The Chairman. What makes the Illinois? Some of the gentlemen of the committee are inquiring.

Mr. Cooley. The two streams, the Desplaines and the Kankakee, form the Illinois, and it is called the Illinois from that point on.

The Chairman. That is at La Salle?

Mr. Cooley. No, sir; this junction is away up at this end of the map [indicating], 18 miles below Lockport.

Mr. Lawrence. From that point on, below Lockport, you call it the Illinois River?

Mr. Cooley. Yes.

Mr. Taylor. That is the Illinois River proper?

Mr. Cooley. That is the Illinois River proper.

The Chairman. There is a little confusion there and I want to get it cleared up. The fact is that the Desplaines River is called the Desplaines River practically until you get down nearly to La Salle; but, in fact, that is the Illinois River when you reach La Salle?

Mr. Cooley. That is the Illinois River at La Salle, but the Illinois River officially begins at the confluence of the Desplaines and the Kankakee.

Mr. Davidson. Is there another stream which comes in at La Salle?

Mr. Cooley. There is a small stream which comes in there, called the Vermilion. The Kankakee and the Desplaines practically form the Illinois. Then there is Fox River which comes in from the north at Ottawa, which drains about 2,500 square miles, and the Big Vermilion comes in opposite La Salle, which drains perhaps 1,500 square miles.

Mr. Davidson. Can you tell us anything about the existing locks, from those maps, on the Desplaines?

Mr. Cooley. This map here (No. 6), if you will pay attention to it, will make clear all the questions that have been asked. Beginning here at Lockport you see the river, and at this point here is the Kankakee coming in [indicating] from the south, a much larger stream than the Desplaines, draining over 5,000 square miles of territory; and from there on it is the Illinois River down past Morris and Marseilles and Ottawa, down to Utica; and on this map is shown the location of the points on the profile, the location of these proposed dams and locks in the river, and along on the north side of the valley is shown the location of the Illinois and Michigan Canal.

The Chairman. Just run the point of your cane along there, Mr. Cooley, and point that out. Mr. Davidson asked about that canal.

Mr. Cooley. It is along the north side of the valley, right under the bluffs [indicating on map], and it reaches the river at La Salle, at this point [indicating]. That canal is 96 miles long from the Chicago River to the city of La Salle; and then you go along on this map farther to the big bend of the Illinois, where it turns southward a distance of 14 miles from La Salle to the beginning of the Hennepin Canal.

The Chairman. I want to clear up all confusion as we go along.

Mr. COOLEY. Yes, sir.

The CHAIRMAN. On the small map here the colors represent the stream down to Utica?

Mr. COOLEY. Yes, sir. At Utica begins the low-grade section of the Illinois River, 230 miles to Grafton, which is simply a problem in dredging. At a point 20 miles from Utica and 14 miles below La Salle, at the big bend of the Illinois at Hennepin, where the river turns southward, is the beginning of the Hennepin Canal, extending over to Rock Island.

The CHAIRMAN. The I. and M. Canal—that is, the Illinois and Michigan Canal—is one thing, and then comes the Hennepin Canal, which is entirely a distinct thing, away down the river. The I. and M. Canal starts above Chicago, as I remember it, from Lake Michigan.

Mr. COOLEY. Below Chicago.

The CHAIRMAN. You call it below; it always seems to me to be above. It comes around and joins the Des Plaines and follows the Illinois down to La Salle, an independent stream with several locks?

Mr. COOLEY. Yes.

The CHAIRMAN. Now, the I. and M. starts away down here by Peoria and goes to the Mississippi.

Mr. COOLEY. That is the Hennepin [indicating]. Here is Chicago, and here is the upper Illinois Valley, including the Des Plaines Valley, through which the Illinois and Michigan Canal extends down to La Salle, not in the river bed at all. At this point the big bend of the Illinois——

The CHAIRMAN. What is that point there [indicating]?

Mr. COOLEY. That is Hennepin. There begins the Hennepin Canal, extending over to the Mississippi River, where you see it on the map [indicating].

Mr. LAWRENCE. That is about 220 miles from this point, at Hennepin, to the Mississippi River?

Mr. COOLEY. Seventy-six miles.

The CHAIRMAN. And that has about 20 locks in it?

Mr. COOLEY. Yes; more than that.

Mr. YOUNG. What was the cause of the commercial failure of this old waterway?

Mr. COOLEY. The old Illinois and Michigan Canal?

Mr. YOUNG. Yes; and the Hennepin, which together made a waterway from Chicago, or near Chicago, to the Mississippi River.

Mr. COOLEY. The Illinois and Michigan Canal has a present depth of about 4½ feet.

The CHAIRMAN. It was intended for 6 feet originally?

Mr. COOLEY. Yes; it was originally intended for 6 feet.

The CHAIRMAN. But it has shoaled up so that I have sounded it, and there are places where there is only 3½ feet.

Mr. COOLEY. Yes; and the locks are only 18 feet wide and 110 feet long, and originally it had a capacity for a boat carrying about 160 tons. Then the Hennepin has been built for a depth of 7 feet and has locks 36 feet wide and 170 feet long.

Mr. HUMPHREYS. Where does the Illinois and Michigan Canal get its water?

Mr. COOLEY. From Lake Michigan.

Mr. HUMPHREYS. How?

Mr. COOLEY. In recent years by lift pumps.

Mr. HUMPHREYS. Water is lifted out of the lake?

Mr. COOLEY. Yes; or rather out of the Chicago River, 5 miles from the lake.

Mr. CASSIDY. Is the canal now used?

Mr. COOLEY. Yes; it is in commission.

The CHAIRMAN. From the big bend in the Illinois across to Rock Island by the Hennepin is how many miles?

Mr. COOLEY. I think it is 76 miles.

The CHAIRMAN. And how far from the big bend to the mouth, where it joins the Mississippi?

Mr. COOLEY. Two hundred and ten miles.

Mr. LAWRENCE. Now, what is the drop in that 210 miles?

Mr. COOLEY. In the total distance it is 28 feet up here to Utica, probably a couple of feet less from Hennepin.

The CHAIRMAN. I want to remark right there that this Hennepin Canal, so called, was started while Mr. Henderson of Illinois was chairman of the Rivers and Harbors Committee—he was the second chairman—and coal was being carried for 11 cents a bushel, and when that canal was completed coal dropped to 9 cents a bushel, and it has been 9 cents ever since.

Mr. HUMPHREYS. On the railroad?

The CHAIRMAN. Yes; on the railroad. It forced a drop of 2 cents a bushel, and it has remained so until to-day. The Hennepin Canal was finished in the nineties, if I remember correctly.

Mr. MADDEN. In order to use the Illinois and Mississippi (Hennepin) Canal effectively and successfully you have got to have some place where the boats can go after they get out of the Illinois and Mississippi Canal?

Mr. COOLEY. That is so. That improvement ends in a neck of the woods.

Mr. YOUNG. The Mississippi River is not navigable from where it runs in?

Mr. COOLEY. Yes; but the canal has no terminus. It does not go anywhere.

Mr. YOUNG. You could go down the Mississippi. There is nothing to keep you from going down the Mississippi.

Mr. COOLEY. No, sir; there is nothing to impede the Hennepin Canal. The only effective connection that it can have is with the Lakes, and that connection does not exist, and it is not available for any useful purpose. But in my opinion with the drainage canal and the state improvement to Utica and the improvement of the Illinois to the Big Bend, at Hennepin, it would make a complete route to the upper Mississippi, and then the Illinois and Mississippi Canal (Hennepin) would develop all of its possibilities; but at the present time it is not worth much. I will leave this map here because I hope every member of the committee will give it attention; I hope you will examine both the map and the profile.

Here is another map [producing map] (Exhibit No. 8) which was also made up by the draftsmen on extra time in the office of the Mississippi River Commission, which is authentic, covering the middle Mississippi, 212 miles, from the mouth of the Illinois to the mouth of the Ohio. It is on a scale of one-half inch to the mile, and shows the river correctly, and the marginal lands and the bluff lines. In that distance, or rather from Grafton down to Commerce, there is 740 square miles of bottom lands, or nearly 500,000 acres of overflow lands. The high water of 1844 generally dominated these lands by from 9 to 11 feet. The map is from official charts, except the section above the Chain of Rocks, 10 miles above St. Louis, to the mouth of the Illinois where a special plate was drawn from other charts to fit this scale. This section of the river differs only 18 miles in length from the lower Illinois.

The CHAIRMAN. I didn't catch the last remark you made.

Mr. COOLEY. I say this section of the river differs from the lower Illinois by only 18 miles in length—and yet it has a declivity of 132 feet at low water as against 28 feet in the Illinois River. I want to call attention to the marked discrepancy in the declivity. I have projected on this map a couple of dam sites, one below St. Louis and one at Commerce, of which I will speak later. I simply wanted to get the course of the river and of the valley in your minds. You will see at the upper end where the confluence of the Illinois and the upper Mississippi is, and about 21 miles below that the confluence of the Missouri. From that point down to the mouth of the Ohio River there is very little tributary territory, and very little increase of flow, so that we take the gauge records at St. Louis for the whole river below the mouth of the Missouri.

I designed to take about fifteen minutes to explain these maps, as preceding a more general and particular argument upon the question of the development of deep water from Lake Michigan to the Gulf of Mexico. In my December statement I covered particularly that division of the route below Cairo—the lower Mississippi, 1,065 miles long, with a declivity of 274 feet—and stated that it is solely a problem of bank protection, coupled with incidental work on bad crossings, and that it is so recognized in all the official reports; that nearly the entire estimate, some $104,000,000, for the improvement of this division of the route is for bank protection. In considering the problem we recognize the fact that there are something less than 400,000,000 yards of material contributed by all the land wash and erosion in the Mississippi basin above Cairo, 400,000,000 yards representing a square mile, approximately 400 feet deep, and that the estimates of what came out of the Missouri amounted to about three-fourths of all this material, or 289,000,000 yards, as originally estimated; that there are 400,000,000 yards estimated to go into the Gulf of Mexico, contributing to the delta at the mouth of the Mississippi; that between the limits of Cairo and the Gulf, almost wholly above Red River, a distance of about 750 miles, there is cut annually from the banks of the stream 1,000,000,000 yards, or two and a half times what comes to the river at Cairo, and two and a half times what leaves it at the delta. The problem of the lower Mississippi is a problem of stopping the local erosion and transportation by holding the banks; that the local erosion and transportation amounts to a cut bank 500 miles long, 100 feet deep, and 100 feet wide per year; that an ordinary bend which would cut a depth of 100 feet and a width of 100 feet, 5 miles long, will produce 10,000,000 yards to be carried on to the first crossing, perhaps, to make a dump amounting to a square mile 10 feet deep, filling up the river 10 feet for perhaps a couple of miles; that the river in high water is constrained in the bends and that the velocities are there the greatest; that the power of the stream is there concentrated, producing these changes in bed and banks.

Where the crossings from one bend to another are much wider, the stream less confined, and the water slacker, there the dump is made; then as the water falls and the volume diminishes, the bends become slack places, the slope of the stream is concentrated on the crossings and proceeds to cut channels through them erratically, sometimes producing confusion below for a number of years; and sometimes that can be corrected by hydraulic dredging, and sometimes it will duplicate the former course. By stopping the cutting of the individual bend some 10,000,000 yards the river will be improved for 10 or 20 miles below by taking away this contribution to the crossings and bars, and that when this treatment had been given the whole stream there would be a radical change in the construction and nature of the stream itself and in the work which it had to perform. It is the official belief—I do not think expressed in print, but I think expressed in conversation; I know I have expressed it publicly—that such treatment would result in not less than 14 feet. There have been some expressions that it might result in a depth of 20 feet. That is a matter that no man can speak of with certainty. No one can say exactly what the effect would be; but this can be said, that the effect would be pronounced and that it will result in some lowering of the river bed; how much we can not say, but it is to be hoped at least enough so that the extreme flood flow will be confined within the banks. I would hope for such a result and believe that it may occur.

The CHAIRMAN. And the engineers generally coincide with that hope?

Mr. COOLEY. Yes; I am speaking rather the consensus of opinion than my individual view on that subject.

Mr. TAYLOR. When you say "flood flow," do you mean an unusual flood?

Mr. COOLEY. Yes; extreme floods.

Mr. TAYLOR. They would be kept within the banks by deepening the channel to 14 feet?

Mr. COOLEY. Yes; I think that may occur. The process which you must employ is going to change the conditions very radically on the lower Mississippi, and we may expect a result of that kind.

The CHAIRMAN. You expressed a thought a moment ago that I would like to see amplified a little, that the improvement of a particular bend to prevent erosion resulted in an immediate improvement of the river at the first crossing below, or practically that.

Mr. COOLEY. Yes.

The CHAIRMAN. And that conveyed the impression to me that you meant to be understood as saying that the eroded material carried in solution did not go far down the river.

Mr. COOLEY. That is, the local transportation.

The CHAIRMAN. Yes.

Mr. COOLEY. The cutting from the bend is largely local.

The CHAIRMAN. In connection with that, will you carry the thought of the volume that must, for instance, come down by the Missouri and deposit itself in the Mississippi; what becomes of it, in other words, on that theory that the local transporation is a short haul, as you might say?

Mr. COOLEY. Yes; exactly. Of course how those quantities distribute themselves we do not know, but we do know this, that practically the equivalent of all that comes into the lower Mississippi at Cairo goes into the Gulf of Mexico; so that what originates between those two points may be treated as local transportation. It may not be identical in all cases; I think it is largely so, because that which comes to the lower river has come a long distance and is in a condition to travel through to the Gulf, whereas that which is eroded locally is largely the coarse material that has been deposited under slackwater conditions in former times.

Mr. TAYLOR. And that precipitates readily?

Mr. COOLEY. Yes; and disintegrates with difficulty.

Mr. MADDEN. And there is as much crosses the bar at the mouth of the river at the Gulf of Mexico as comes in from the Missouri and the Ohio?

Mr. COOLEY. Yes, sir; a little more, I think.

Mr. HUMPHREYS. What effect would this deepening of the channel have on the low-water level?

Mr. COOLEY. As I stated, it would probably lower the river bed and also the low-water line quite materially; how much, I can not say.

Mr. HUMPHREYS. About what effect would that have, then, on the level of the tributaries of the Mississippi?

Mr. COOLEY. Well, it will make trouble in that particular tributary that we are considering, from Cairo up to Commerce, and that is a matter to which I will have something to say a little later. But there is a difference in condition there as compared to the other tributaries that I know of.

Mr. HUMPHREYS. What I was wondering about was this: If the low-water level of the river is affected materially below Cairo, what effect would it have, for instance, on the Arkansas and the White and the Yazoo and the Red?

Mr. COOLEY. My impression in regard to those streams, although I can not speak from having looked them up recently, is that their lower reaches within the flood effects of the Mississippi River—backwater effects—are of very low grade, very low declivity, and the effect there would not be so material as it would be in both the middle Mississippi between Cairo and Commerce and in the Ohio between Cairo and Chain of Rocks below Metropolis.

A lowering of 10 to 20 feet, which I would think was within the possibilities, would concentrate slopes upstream in a manner which would have to be cared for.

Mr. SPARKMAN. Do I understand you to say that this 14-foot depth would take care of the high-water in the Mississippi River below Cairo?

Mr. COOLEY. I want to make a clear distinction there, if I can. The point that I was about to make was that to improve this river you have to do it in a certain way, to hold these banks; that you treat the river itself as a condition without any regard to the depth that you are going to produce; and the cost of treating that river is entirely independent of the depth that you are going to produce.

Mr. SPARKMAN. The treatment consists of revetting the banks and probably some dredging?

Mr. COOLEY. Some training and possibly dredging on the crossings, so that the question does not enter whether the depth is 9 feet or 14 feet or any other depth. That comes incidentally to the manner of the treatment.

Mr. YOUNG. The cost of revetting is just the same, in other words?

Mr. COOLEY. Yes.

Mr. MADDEN. In other words, when you confine the channel you create the depth?

Mr. COOLEY. Yes.

Mr. MADDEN. Regardless of whether you start out to create the depth or not?

Mr. COOLEY. That is true, absolutely.

Mr. SPARKMAN. They have those levees along the lower Mississippi for the purpose of confining the water?

Mr. COOLEY. Yes.

Mr. SPARKMAN. Now, what I wanted to get at was whether in revetting these banks and confining the stream these overflows would be prevented.

Mr. COOLEY. My idea is that if you stop this enormous amount of material from going into this river bed every year these bars will work down and the plane of the river will go down, but more at low water than at high water, and the river will run at a lower level, and I am inclined to think that it may be so that it will bring the high water horizon within the bank level.

Mr. MADDEN. You have been dealing with the lower Mississippi River, and you stated to the committee that it did not make any difference what depth you contemplated?

Mr. COOLEY. Yes.

Mr. MADDEN. That you would reach the depth by confining the channel, anyway?

Mr. COOLEY. Yes.

The CHAIRMAN. That was where there was a permanent improvement?

Mr. COOLEY. Yes; that is fixed by the physical conditions.

Mr. MADDEN. Now, how does that statement of the case apply to the Mississippi River between Cairo and Greenfield?

Mr. COOLEY. I was just coming to that proposition. I am through with the lower Mississippi. I have said all that I intend to say, except in response to questions.

The CHAIRMAN. Just one question. That proposition is theoretical engineering, is it not? Can you give us an illustration of a stream similarly situated where the permanent improvement has resulted in dredging so as to lead you to believe that it may be any depth from 14 to 20 feet?

Mr. COOLEY. No, sir; I can not. I can cite you some cases of the lowering of a river bed from the improvement, like that of the Saone, at Lyons. The lock at that point has been lowered three times to meet a lower plane of the river, to meet the conditions that are produced by regulation. In the harbor of St. Louis it is clearly pointed out in the reports that the plane of low water there has been lowered about 4 feet already by the comparatively nominal work that has been done in regulating the stream below St. Louis, and how much lower it may go we can not tell.

The CHAIRMAN. Have you been over that stream, the Missouri, from Jefferson City down to Gasconade?

Mr. Cooley. No, sir; not in recent years.

The Chairman. Are you familiar with it?

Mr. Cooley. I slept on the Missouri River for several years, but I have not been on it for fifteen years, so that I do not know what the results have been there, on that stretch. I know that the Missouri River Commission, under the initiative of my old chief, Colonel Suter, started out to see what they could do with a reach of the Missouri River between Kansas City and the Mississippi, but I have never known what the result of the work has been.

Mr. Madden. The engineer who had charge of the Missouri River improvement came on from Kansas City and appeared before the committee, and he stated the other day—I think it is no secret—that within that 45 miles of the Missouri River which was revetted, while it was revetted with the idea of getting a 6-foot channel, as a matter of fact the channel in most of the 45-mile stretch was 20 feet or thereabouts.

The Chairman. It was from 14 to 24 feet deep.

Mr. Cooley. Well, gentlemen, that is an interesting proposition, if true, and I commend it to your attention in connection with this problem.

Mr. Woodyard. You spoke of the deepening of the channel of the lower Mississippi. In your judgment would it necessitate any material increase for the 9-foot stage in the Ohio which has been recommended, and if so, to what extent?

Mr. Cooley. No, sir; if that matter develops you will simply have to put in an extra dam, probably, to overcome it. It would not change the nature——

Mr. Woodyard. Of the improvement as a whole?

Mr. Cooley. Of the improvement as a whole, no, sir; and the Ohio River from Metropolis down to Mound City has rock outcropping in the bed at intervals, so that the construction of dams there would be a very easy matter.

In regard to this division between Chicago and Cairo, 539 miles, with a total fall of 306 feet, we have three divisions. The Chicago divide and the Rock Bound Valley, which is covered by the actual and proposed work of the State of Illinois and its agents, has a length of 97 miles, and is certainly the most costly division of the whole route. There we have 146 feet fall, from which the Sanitary District and the State of Illinois expect to realize a tremendous horsepower. Then we have the lower Illinois, 230 miles, with this extremely low declivity of 28 feet, over which, if we have any regard for the conservation of the lands and the salubrity of the valley, any regard for the future maintenance of the channel, we must produce at least 14 feet in order to maintain a permanent channel on this low grade. If we do produce more it will be better. That, however, is an inexpensive matter. To produce a channel of 14 feet, with the flow line at approximately the low-water level, this channel, 300 feet wide on the bottom, will involve the dredging of about 100,000,000 yards of the easiest kind of alluvium, and will cost for the actual work not to exceed $5,000,000. Alluvium which I think is not greatly different in character has been handled in St. Peter on the St. Lawrence for about 3 cents a yard. So that a deep channel over that stretch can be produced at a nominal cost, as compared with other divisions of the route. What has already been expended in work by the Sanitary District of Chicago and what Illinois is authorized to expend, by a vote of the people, and what must yet be expended to complete the work at Chicago, amounts to about $100,000,000; and with the addition of $8,000,000 to $9,000,000 for the construction of locks, and $5,000,000 through the lower Illinois Valley for dredging—the official estimate is $8,000,000 ($8,187,682), and I prefer you to take that because there may be other things to do besides dredging—you will require $16,000,000 additional to carry 14 feet to the mouth of the Illinois, 327 miles from Lake Michigan, and you will have for a distance of over 41 miles the full depth of 24 feet.

The CHAIRMAN. Forty-one miles?

Mr. MADDEN. From Chicago down to Lake Joliet.

Mr. COOLEY. The Chicago Sanitary Canal is 24 feet, and this Joliet level we propose to make 24 feet at the outset. We propose to make the 5 locks 14 feet deep down to Utica, with a channel 14 feet deep below the Joliet level to Grafton, at a cost to the United States of about $16,000,000, in round numbers. I want to call your attention to the fact that in 1889, when we passed the Sanitary Canal law in the State of Illinois, we had an official report for a canal and river improvement covering 102 miles, between Lake Michigan, at Chicago and La Salle, at an estimated cost for 8 feet of $26,873,008, and for a depth of 14 feet of $38,263,763. There were to be 16 lift locks and 3 guard locks 350 feet long and 75 feet wide.

Mr. MADDEN. Who made that report?

Mr. COOLEY. Capt. W. L. Marshall, who is now General Marshall. The 1905 report of the 14-foot board estimated a 14-foot channel with 9 locks, 600 by 80 and 20 feet deep, between Lockport and Utica, at $16,731,900 and $8,187,682 additional for the lower Illinois, making a total of $24,919,582 between Lockport and Grafton.

The point I wish to bring out in this connection is, that the United States, in cooperation with the State of Illinois, can produce a depth of 14 feet with locks and structures and rock cuts, for a depth of 24 feet, for a great deal less than what it would have cost the Federal Government originally to produce 8 feet through the valley. I do not wish to argue any question before the committee, because arguments take time.

Mr. MADDEN. May I ask you a question there?

Mr. COOLEY. Certainly.

Mr. MADDEN. Did the survey which was reported by Captain Marshall, who is now General Marshall, go beyond La Salle?

Mr. COOLEY. No, sir.

Mr. MADDEN. Then it was about $27,000,000 from La Salle to Chicago?

Mr. COOLEY. Yes, sir.

Mr. MADDEN. The cost to the Federal Government, if it should join the State of Illinois to the extent of building the locks between the end of the drainage channel at Joliet and Utica or La Salle, would now be only $8,000,000?

Mr. COOLEY. The figures are approximate.

Mr. MADDEN. And for which we would get a 24-foot and a 14-foot channel?

Mr. COOLEY. A 14-foot channel below the Joliet level and structures for a 24-foot channel.

Mr. MADDEN. And structures for a 24-foot depth?

Mr. COOLEY. Yes.

Mr. MADDEN. Whereas the report made, to which you have just referred, contemplated only a 9-foot channel?

Mr. COOLEY. An 8-foot channel.

Mr. MADDEN. At a cost of $27,000,000?

Mr. COOLEY. Approximately.

The estimates which I made, as consulting engineer of the Internal Improvement Commission of Illinois, were printed by order of the lower house of the general assembly, and an abstract thereof is entered on the profile (Exhibit No. 6). These estimates amount to $24,167,871, to which must be added interest account and administrative charges, which would bring the total above $27,000,000, and I have usually taken the round figures at $28,000,000. Of this total, $5,000,000 is allowed for water-power rights and $8,103,800 for the locks. This is, however, a net estimate for the locks without the usual percentage for contingencies. The State has $20,000,000, with $8,000,000 to be provided, which happens to be just about the estimate for the locks.

Mr. MADDEN. And these locks, by the way, if you will allow me to interrupt you there, which are estimated to cost $8,000,000, are projected to be 1,000 feet long, 110 feet wide, and 24 feet deep, are they?

Mr. COOLEY. The actual estimate was made on a lock 108 feet wide and 960 feet clear length, which would be a couple of feet narrower, and practically the same length between quoins.

Mr. MADDEN. What is the reason for the extraordinary width of the locks? Are there any ships anywhere sailing the Lakes or any of their tributaries that are over 100 feet wide?

Mr. COOLEY. Yes; some of the boats of the Detroit and Cleveland Navigation Company are more than 100 feet over the guards; they are running from Detroit to Cleveland and from Detroit to Buffalo.

Mr. MADDEN. What is the nature of their business?

Mr. COOLEY. Passenger, express, and general freight business. The Detroit and Cleveland Navigation Company is a very successful business that has been built up from a couple of old tubs that ran between Detroit and Cleveland. Last year they carried 16,000,000 passengers, running six lines. I do not know how many boats there are in the fleet.

Mr. MADDEN. Are they competing successfully with the railroads?

Mr. COOLEY. Yes; in both express, freight, and passenger business.

Mr. LAWRENCE. My understanding was that this $28,000,000 would give you a channel depth of 14 feet and locks 24 feet over the miter sill.

Mr. COOLEY. Yes, sir.

Mr. LAWRENCE. At a proposed expense of $20,000,000 to the State of Illinois and $8,000,000 to the National Government?

Mr. COOLEY. That is correct.

Mr. YOUNG. What do I understand your estimate is of the detailed expense to the Federal Government of this entire project from Chicago to Cairo?

Mr. MADDEN. He has not spoken of the Cairo end of it yet.

Mr. COOLEY. I want to take a little time for that. The estimate is $56,000,000.

Mr. LAWRENCE. This estimate of $28,000,000 includes the distance to Utica?

Mr. COOLEY. Yes, sir.

Mr. YOUNG. But your estimate for the entire distance is only $56,000,000?

Mr. COOLEY. To Cairo; yes, sir. I will take that up in a moment, because I want to finish with the Illinois division now. I wanted to say, however, in regard to the Illinois proposition, within the limits of the State the estimate was $8,000,000 for the locks down to Utica, and $8,000,000 was the official estimate from there to Grafton; and $16,000,000 would do a very handsome job of the whole business, in cooperation with the State.

The CHAIRMAN. What was that last estimate—from Grafton to St. Louis?

Mr. COOLEY. No, sir; from Utica to Grafton; we are within the Illinois limit now. About $8,000,000 was the official estimate there.

The CHAIRMAN. You did not mention the cost from Grafton to East St. Louis.

Mr. COOLEY. No; I am going into that now. As soon as we get through with the Illinois proposition I will go into the middle Mississippi.

The CHAIRMAN. What is the depth carried by the drainage canal?

Mr. COOLEY. 24.4 feet at low-water of Lake Michigan. At the average stage of the lake it would be 26 feet. That is practically the datum that the Soo Lock is built on, at the average stage. We are about 1½ feet deeper than the last lock proposed at the Soo.

The CHAIRMAN. What is the discharge at Lockport now?

Mr. COOLEY. The present discharge is limited, on account of the improvements being incomplete in the Chicago River, to 4,200 second-feet.

The CHAIRMAN. But you have taken more than that?

Mr. COOLEY. Yes, we have taken 6,000 feet and upward; but the capacity of the rock cut is designed for 14,000 feet.

Mr. MADDEN. Have we authority to take as much as 10,000 feet?

Mr. COOLEY. I think we have authority to take 15,000 feet, or any other quantity.

Mr. LAWRENCE. Is your proposition with reference to 24-foot locks made looking forward to a 24-foot channel ultimately?

Mr. COOLEY. Yes, sir.

Mr. LAWRENCE. Have you made any estimate at all as to what would be the ultimate expense of increasing that channel from 14 feet to 24 feet?

Mr. COOLEY. Over the constitutional stretch?

Mr. LAWRENCE. Yes; from Lockport to Utica.

Mr. COOLEY. Yes; $13,000,000 ($13,063,302) would give a channel 24 feet deep and 360 feet wide on bottom. I omitted to say that in all our projects we had contemplated an ultimate 24-foot channel, and we have estimated the bridges for 400-foot spans, 180-foot openings on each side of the draw.

Mr. LAWRENCE. That, of course, would give you a waterway that can be used now by boats traversing the Lakes?

Mr. COOLEY. Yes; the channel would be 360 feet wide on the bottom and 24 feet deep, and the river itself is generally 600 feet or more in width. That is the basis of our project, and we simply develop now a channel 14 feet in depth and 200 feet wide below Joliet.

Mr. MADDEN. Will you allow me to interject a suggestion there?

Mr. COOLEY. Yes, sir.

Mr. MADDEN. It is contemplated by the State of Illinois, is it not, that if the Federal Government should cooperate with the State in the construction of this channel, and the State should spend $20,000,000, the State will make the channel that it makes through the rock section 24 feet deep now?

Mr. COOLEY. Yes.

Mr. MADDEN. Regardless of what the project may contemplate?

Mr. COOLEY. There is no disagreement in our State on that proposition. All the estimates have been made on the basis of 24 feet for the rock cuts.

Mr. MADDEN. And the reason why we do it now is, I suppose, that it is a good deal more economical to cut the rock in the dry than it would be to cut it in the wet?

Mr. COOLEY. Where you have got massive rock, massively bedded, you can dig 3 yards of rock in the dry for 1 yard in the wet; that is the reason for it. And, besides, you get a smooth and regular channel, whereas if you cut it in the wet you get a rough and irregular one.

Mr. CASSIDY. You think you will have a 24-foot channel from Lake Michigan to the Gulf?

Mr. COOLEY. Yes; eventually.

Mr. CASSIDY. How far in the future do you look for that?

Mr. COOLEY. After we produce a 14-foot channel and have all the structures built for 24 feet it is just simply a question of when you are willing to spend the money necessary for it. I will cover that point later.

There are one or two little points that I wish to bring out as a matter of record. The organic law constituting the sanitary district of Chicago makes the channel already constructed navigable waters, and gives jurisdiction over it to the United States whenever the United States shall undertake the improvement of the rivers below so as to connect therewith; so that it becomes as much a part of a federal project as if the Federal Government had itself constructed it.

Mr. DAVIDSON. Provided the Federal Government complies with all the conditions of the organic act?

Mr. COOLEY. There are no conditions in that organic law except that Chicago shall have the uninterrupted use of it for sanitary purposes; that is the only condition.

Mr. MADDEN. As a matter of fact, the United States Government now has assumed jurisdiction over the Illinois River for navigation purposes?

Mr. COOLEY. Yes, sir.

Mr. MADDEN. And they allow no boat to run on the Illinois River that carries a captain or engineer who has not a government license, and they allow no boat to run on the Illinois River which has not passed the customs, both for the hull laws and the boiler laws?

Mr. COOLEY. That is absolutely true up to Utica, and above that we have fixed bridges, which are about to be changed to drawbridges at Utica and Ottawa.

Mr. MADDEN. Below that it is a navigable stream?

Mr. Cooley. Yes.

Mr. Taylor. Is there any difference between that and all the other navigable streams?

Mr. Cooley. No, sir. Between Lockport and Utica it is contemplated, and I assume that legislation will take that form, that everything that the State of Illinois does will be turned over to the General Government, except that required by the State to maintain and operate water powers.

Mr. Cassidy. What was the result of the litigation in which Mr. Walter Reeves was interested, at the mouth of the Des Plaines, I believe?

Mr. Cooley. We got a mixed judgment on that. The state court declared that the Des Plaines River was not a navigable stream, and the matter stands there, with a new suit initiated in the United States circuit court and with orders to appeal the state case whenever the federal case reaches the point where the two issues can be joined.

Mr. Cassidy. What does that suit contemplate?

Mr. Cooley. That contemplates eventually getting a decision in the Supreme Court of the United States as to whether the supreme court of Illinois has properly decided the question, and also a decision on the merits of the question.

Mr. Davidson. That is, as to the navigability of the stream at that point?

Mr. Cooley. That is the particular point at issue—the navigability of the Des Plaines River. I think, gentlemen, I have covered everything on the Illinois from Chicago down to Grafton. I wish to say that $13,000,000 additional will produce that 24 feet in this ample channel of which I have spoken, down to Utica, and that $7,000,000 additional will extend that 24 feet to Grafton, making a total of $20,000,000 for 24 feet to Grafton, above the estimates that we are now considering.

Mr. Cassidy. That is, above the $56,000,000?

Mr. Cooley. That is above the $16,000,000 that we are asking the Government for between Lockport and Grafton.

Mr. Madden. So that, as a matter of fact, if the Congress of the United States should adopt your view of the case and put in the locks with 24 feet over the miter sill, having in view the future needs of commerce and the necessity for a 24-foot channel all the way down, the total extra cost above the $16,000,000 to which you have called our attention would be only $20,000,000?

Mr. Cooley. Yes, sir; and to get the matter in its broader bearings I want to call your attention to the statement that the Sanitary District and the State of Illinois together, when this project is realized, will have expended $100,000,000 and the Government will have expended $16,000,000, making a total of $116,000,000, and that the $20,000,000 is an additional sum which is relatively small for the additional depth.

Mr. Young. So that the total cost to the United States would be $36,000,000?

Mr. Cooley. For 24 feet to Grafton.

Mr. Young. According to that estimate?

Mr. Cooley. Yes, sir; 24 feet. But we only ask now for the little additional cost involved in making the locks so as to meet that possibility.

Mr. CASSIDY. How much do you figure that extra cost to be?

Mr. COOLEY. The board of engineers estimated for those nine locks, I think, $5,600,000 ($5,745,430).

Mr. CASSIDY. A matter of $2,400,000?

Mr. COOLEY. Yes; about that.

Mr. MADDEN. The Board of Engineers also stated when they made the estimate that if the future needs of commerce should require a greater depth, the locks built under their estimate would all have to be taken out, and that the cost of the construction of locks later would be infinitely greater than if built now. They virtually recommended that the locks should be built 21 feet, and submitted an additional estimate which made the total for locks about $7,100,000, as I remember the figures.

Mr. CASSIDY. On the basis of 21 feet?

Mr. COOLEY. On the basis of 20 feet, and the estimate was $7,121,430.

Mr. MADDEN. Now, the cost for a lock for 20 feet above the cost of a lock for 14 feet would be only about $1,300,000 more; is that right?

Mr. COOLEY. One million three hundred and seventy-six thousand dollars.

Mr. DAVIDSON. What would be the flow in that channel with 24 feet?

Mr. COOLEY. It would be the 14,000 feet plus the natural flow of the stream.

Mr. CASSIDY. Would a less quantity than 14,000 feet suffice for the purposes of navigation, leaving out sanitary conditions?

Mr. COOLEY. So far as the river is locked and dammed, down to Utica, yes. On this declivity that exists from there to Grafton you need this volume of water.

Mr. CASSIDY. That is, you need 14,000 feet; or could you get along on what you now have? I think the authorized amount now is 4,167 feet, is it not?

Mr. COOLEY. The volume now permitted is 4,200 feet, but this is simply conditioned on the present capacity of the Chicago River. As a matter of fact, 10,000 feet has been conceded, and we are at liberty to reach that whenever the river improvement is sufficient to pass that volume.

Mr. CASSIDY. Has there been a grant by the War Department or by any commission—has there been any authoritative grant by the War Department—for you to take 10,000 feet?

Mr. COOLEY. The report of the International Waterways Commission recommends that Chicago be allowed to take 10,000 feet.

The CHAIRMAN. When it reached the number of population under the drainage act?

Mr. COOLEY. Yes, as I understand it.

Mr. CASSIDY. But, as I understand it now, you have conditions there for 4,157 feet?

Mr. COOLEY. Yes; 4,200 feet. As soon as we have the present scheme of improvements carried out that will be raised to 7,000 or 8,000 feet per second. Really, on the basis of population now it requires a much larger volume than we are now taking.

The CHAIRMAN. I did not catch what you said last.

Mr. COOLEY. I said we are not up to our population requirements now in the water that we are taking.

The CHAIRMAN. You are not up to your population requirement in the water you are using?

Mr. COOLEY. No, sir.

The CHAIRMAN. In other words, you are using more water——

Mr. COOLEY. We are using less.

The CHAIRMAN. Using less?

Mr. COOLEY. Yes.

Mr. CASSIDY. Is there not a suit pending now, brought by the United States against the drainage commission, involving that question?

Mr. COOLEY. The commission proposed to open up a branch channel from the Calumet region through what is known as the Sag route, and to take 4,000 feet of water through that channel, in addition to the 10,000 feet reserved for the Chicago channel, that amount being mentioned as the minimum in the organic law. The permit for that was denied by the Secretary of War, and then an agreed suit was brought to test the power of the United States to refuse that permit, and that suit is now pending.

Mr. CASSIDY. Are you prepared now to discuss, or will you do so later, the effect on the lake levels of the withdrawal of 14,000 feet?

Mr. COOLEY. Yes; I will do so if anybody wishes to hear me on that question.

Mr. CASSIDY. I should like, before you get through, to hear what you have to say on that subject.

Mr. COOLEY. I will take that up later.

The CHAIRMAN. The committee will now take a recess until 3 o'clock. I want to say that personally I have been very, very much interested in what Mr. Cooley has presented. It is more interesting than a lecture, and it is, it seems to me, particularly useful for this committee. I hope before another year that every member of this committee will have gone up and down the Mississippi and up and down the Missouri and up and down the Illinois and the Des Plaines rivers, so that we can all have the benefit of the object lessons there.

(At 1 o'clock p. m. the committee took a recess until 3 o'clock p. m.)

AFTER RECESS.

The committee reconvened at 3 o'clock p. m., Hon. De Alva S. Alexander (chairman) presiding.

STATEMENT OF MR. LYMAN E. COOLEY—Continued.

Mr. COOLEY. Gentlemen, if I made myself clear this forenoon, it is apparent that by reason of the conditions attending on the work from Chicago to Utica, and by reason of the physical conditions attending on the lower Illinois, 14 feet is a necessity of the situation down to Grafton, and it involves $16,000,000 only on the part of the United States. If I made myself clear, you are to produce 14 feet or more below Cairo, as any proposition for permanent improvement necessarily involves the protection of the banks. Then we have left the problem of the division between Grafton and Cairo, a distance of 212 miles, with a declivity of 132 feet, or about one-eighth of the total route from Lake Michigan to the Gulf of Mexico. This division of the river has a fall of about 7½ inches per mile. The river could as well or better run on a fall of 2 inches to the mile. In time of great floods the fall would produce 50,000 horsepower per mile, when only 10,000 to 15,000 horsepower is required for the stream in a proper channel, or in a channel similar to that which exists in the lower Mississippi River between Red River and the Gulf of Mexico. The result is that you have a surplus of 30,000 to 40,000 horsepower per mile in great floods, which is engaged in dissipating the channel, tearing up the bed and banks, so that you have only 3 to 4 feet in the natural condition of the stream at extreme low water. Such a surplus of energy would propel a vessel one-eighth of a mile long across the Atlantic Ocean at 20 knots; put it into hydraulic dredges and you would not recognize the bottom lands after the first season. That is the trouble with the middle Mississippi. The Board of Engineers of 1905 projected a dam at Alton with a canal 18 miles long leading across the Illinois bottom lands opposite the mouth of the Missouri to the harbor of St. Louis, above the Merchants' Bridge, at an estimated cost of about $7,000,000 for 14 feet. The last board, reporting in July, 1909, proposed a number of methods for producing 14 feet from St. Louis to Cairo. One of them was by means of locks and wicket dams, ten in number, from St. Louis to Cairo, similar to those proposed for the improvement of the Ohio River, at an estimated cost of $25,000,000, which, together with the proposed works above St. Louis, would make a total of $32,000,000 for this division.

Another method was the German method by means of ground sills, by which not only the banks of the river are fixed in position, but also the bed. This would give an open channel below St. Louis of 14 feet, and the estimate therefor was $53,000,000, which, together with the estimate above St. Louis to Grafton, would make a total of $60,000,000 for this division of the route. The board, however, recommends the adoption of an 8-foot project at a cost of $21,000,000, and in that connection estimates a dredging fleet that would cost $3,600,000, and $1,500,000 per year for operating this fleet, in order to maintain 14 feet of water. If we assume that that fleet is to be operated for twenty years, until you are prepared to do something else, the amount will be $54,500,000. But the board makes a suggestion. Up to a certain point the board seems to have considered the problem as an engineering proposition solely to see how best to produce 14 feet of water, and it entertained and presented in detail all the available methods. They appear to have concluded, as wise engineers, that the future of the country would demand more than 14 feet, and therefore that this proposition for locks and this proposition for ground sills, thus fixing the bed of the river, ought not to be entertained, because it would make a positive limitation against further development, and they so state. Up to this conclusion I fully concur with them, that we ought not to limit the possibilities of progressive development in this stream. The board does not seem to be clear as to what the ultimate plan should be, and seem to suggest the need of further consideration. The board then takes up the commercial side of the question, and from this point of view they make a positive recommendation for 8 feet. The report appears to have been drawn as an engineering report first and later on modified to suit certain commercial ideas.

I am entirely clear that we ought to project the work for the middle Mississippi for an ultimate development of 24 feet. The question is, How can it be done? The consideration of the problem leads to a proposition so bold that it tries a man's nerve to present it. I remember in 1894 that a distinguished chairman of this committee, Gen. T. C. Catchings, of Mississippi, came to Chicago, and knowing me personally I took him over the Chicago Drainage Canal when we had 20,000 men in the valley and machinery and appliances working galore. After spending a couple of days there and coming to the office and studying the plans, he said this, "Mr. Cooley, if I had had the wit, nothing would have pleased me more than to have spent three years of my life in incubating and working up a project of this character; but do you know what I should have done after I had completed my task? I would have reflected that every one would have called me the blankest idiot in the United States, and I would have filed those plans safely in the vault and gone away and tried to forget about it." Now, I hope that what I am about to present will not produce the effect that General Catchings feared. I can bear witness that General Catchings was right, and that certain men were called as many kinds of an idiot for many years, as Vanderbilt's son-in-law. I hope that the attitude of the committee when I am through will be like that of Alderman Husband. When I was editor of the American Engineer, in 1884, there came into the office a report of the banquet held at Manchester when the bill authorizing the Manchester Ship Canal passed Parliament. One of the speakers on that occasion was Alderman Husband, and among other things he said this, that he had always believed in the project, but he had foreborne heretofore to express his approval, for fear that a man of sense would be made to appear ridiculous. [Laughter.]

Mr. Lawrence. Go ahead and be brave, Mr. Cooley; we will at least hear what you have to say.

Mr. Cooley. On this map (Exhibit No. 8) you will see a couple of red bands, one across the river at Jefferson Barracks, 8 miles below the Eads Bridge at St. Louis, the other at Commerce, 131 miles farther down and 36 miles above Cairo Point, where I propose to locate dams. Bed rock is at a suitable elevation for the St. Louis dam, and it is proposed to build the dam so as to raise the water level 26 feet above low water in St. Louis Harbor, and to so design this dam that all flood volumes, even including that of 1844, will pass on a limit not exceeding 15 feet above the crest of the dam and ordinary floods within a limit of 10 feet. To produce a free discharge over this dam, it is necessary to lower the river bed below. Nature would do this automatically in the course of time, but engineering art can and should expedite the result. You will then be able to control the level of the waters above the dam within the present flood limits. The dam would back the water on a level line up to the mouth of the Illinois, 45 miles above its site, and actually raise the low water at the mouth of the Illinois about 4 feet and accomplish the purpose proposed by the Alton dam; it would do away with the dam at Alton; it would do away with any canal construction and set the water up the Mississippi some distance above the mouth of the Illinois and up the Missouri about halfway to St. Charles.

Mr. **Lawrence**. Will you state about what the effect would be at St. Louis?

Mr. **Cooley**. The crest of the dam will be 28.4 feet above low water at the site, and it will produce through St. Louis Harbor for 15 miles a depth of more than 30 feet. It will make an ideal harbor for St. Louis in that it will be possible, as on rivers abroad and in the commercial docks abroad and on the Lakes, to have vertical docks, which will be ideal for business.

By lowering the river bed below this dam by 12 feet we will have a head there of 40 feet at low water. We will have at all times a head sufficient to produce a water power, except possibly in such floods as 1844 and 1903, which occur perhaps twice in a century, which might interfere for a short period.

The present reliable low-water volume of the Mississippi River passing St. Louis is 41,000 feet per second, below which the river has averaged only 1.2 days a year in the past forty years. The increment from the Great Lakes is to be 14,000 feet, bringing the volume up to 55,000. You would thus produce 200,000 horsepower at this dam.

Mr. **Madden**. At that point?

Mr. **Cooley**. At that point. Incidentally, you would correct serious difficulties which are showing up in the St. Louis Harbor situation, difficulties which are mentioned in the report of the district engineer. The district engineer, Colonel Bixby, was the chairman of the board of 1909. It is proposed to put in ground sills through St. Louis Harbor, to make some changes in the cross section there, in order to obviate the difficulties which have arisen through the lowering of the river bed. In other words, the effect of the present improvement has been bad at St. Louis in respect to the harbor conditions there.

The second dam is to be at Commerce, and this site was first considered by reason of what seemed to be the physical conditions below Commerce. The St. Louis site came in as a corollary. The river passes through a rock gorge for several miles between Grays Point and Commerce similar to the one the Mississippi River passes through at Keokuk and also at Rock Island. Below that gorge is a very steep declivity to the Ohio River, a distance of 36 miles, with a fall or more than 31 feet, or almost a foot to the mile, making regulation there extremely difficult. If the Mississippi River should be lowered by the effect of works therein by 10 feet at Cairo, that declivity would be increased to 40 feet, or over a foot per mile, which would add greatly to the difficulties of improving that portion of the stream. If Greenfield Bend should cut off opposite Cairo—and the danger of its cutting off would be greatly accentuated by increased slope in that section of the river—it would absolutely wipe Cairo off the map, shortening the river by 12 miles. In other words, you would have a possible slope of 2 feet to the mile on a river length of 24 miles. There is no way of meeting the situation as I see it, except to build a dam at Commerce which will limit the effect upstream of these probabilities. I put this dam provisionally at 10 feet (10.3) above the bank-full stage, and nearly 2 feet (1.8) above the high water of 1844, so that this dam would have a free fall under flood conditions, without lowering the river bed; in other words, no conditions obtaining in the Mississippi River below the dam would affect the conditions above it. If you lowered the river bed, which on this steep slope is a much easier matter than below St. Louis, by 8 feet, you will have a fall of 40 feet and you will produce there, with the same volume of water, 200,000 horsepower at all seasons of the year.

Mr. DAVIDSON. That 10 feet above bank-full stage is how much above low-water stage there?

Mr. COOLEY. Thirty-two feet. The effect of so high a dam is considerable at high water. It will back the water up as far as Grand Tower in flood times, and raise it on the lower part of the bottoms by 7 or 8 feet. That is the bank-full stage; high water of 1844 it would not affect so much. There is less than 60,000 acres of land, or about one-eighth of the bottom lands in the middle Mississippi, that will be particularly affected. You can condemn it or build levees and reclaim it, the same as on the Illinois River. The lands are not necessarily destroyed. The low-water pool will extend nearly to Chester, halfway to St. Louis. The new declivity which will now exist between the crest of this dam and the foot of the St. Louis dam, due to the raising of the water by the dam and the lowering of the river bed at the upper end below the St. Louis dam, will be 30 feet between the two dams, in place of about 74.6 feet, which is what exists in nature. That represents the change in the low-water declivity; not so much diminution at high water. I have no hesitation in saying that, with this change in the declivity, 14 feet would result automatically in time. It might take time, but with engineering aid it can be produced perhaps as quickly as by any other method. The net result is this, that you have taken out of the river about 80 feet of its total fall, leaving only 52 feet of a declivity; that you have produced 14 feet of water or more; that you have everything in shape with your locks down to the proper horizon from ultimate depth of 24 feet; and as far as I have had time to go into the estimates, I judge—I do not state that positively—that it can be done for $40,000,000.

Mr. MADDEN. As against $60,000,000 according to the estimate for the plan proposed of an open channel, by the government engineers?

Mr. COOLEY. Yes.

Mr. LAWRENCE. That $40,000,000 includes the construction of two dams and two locks?

Mr. COOLEY. Yes.

Mr. KENNEDY. What do you estimate the dams would cost?

Mr. COOLEY. Forty million dollars

Mr. KENNEDY. And that without the construction of any levees? That does not include that?

Mr. COOLEY. Yes, sir.

Mr. KENNEDY. It does include that, too?

Mr. COOLEY. Yes, sir.

Mr. KENNEDY. What do you estimate for the dam?

Mr. COOLEY. I would state that figure at this time with a plus uncertainty of 25 per cent; in other words, I would say that it would not exceed $50,000,000, but I hope after examining the matter finally and making up blotter sketches that the figure will come down to the amount just stated.

Mr. MADDEN. According to the plan which you have now suggested, you can create a positive 14-foot depth between St. Louis and Cairo?

Mr. COOLEY. Yes, sir

Mr. MADDEN. And create 400,000 horsepower?

Mr. COLLEY. Yes.

Mr. MADDEN. With an expenditure of $40,000,000, with a possible addition to that of $10,000,000, making $50,000,000 in all?

Mr. COOLEY. Yes, sir.

Mr. MADDEN. As against an open-channel proposition of the government engineers at $60,000,000?

Mr. COOLEY. Yes, sir.

Mr. RANSDELL. What would be the effect on the sediment coming out of the Missouri River of those two dams there? What would become of that sediment?

Mr. COOLEY. These dams will not create ponds. If they created ponds the ponds would fill up. You are simply re-forming the channel on a less declivity, and that re-formed channel would have the same relation to the old channel that the channel below Red River has to the Mississippi River above. It runs out there 300 miles on a declivity of one-seventh of a foot to the mile and 180 to 240 feet deep and 2,000 to 1,700 feet wide at low water, absolutely without any declivity at all, passing all the sediment that comes from the continent into the Gulf of Mexico without difficulty and with no current practically in low-water seasons. The Gulf of Mexico is virtually a dam. The middle Mississippi can run on 2 or 3 inches to the mile in a channel much narrower than now, and naturally under those conditions it will be much deeper; and the object of making this low declivity is to enable this tendency to be set up and work out automatically, but probably engineering art will be required to expedite and direct the ultimate solution.

Mr. RANSDELL. Down there you have the continuous deep water for this sediment to pass along the bottom of the river, to flow on to a constantly deepening channel, but up here you would have these two great dams that would rise pretty nearly to the top of the river, with only a slight depth passing over the dams.

Mr. COOLEY. Ten or 15 feet.

Mr. RANSDELL. Would that take all of this sediment?

Mr. COOLEY. Yes, sir.

Mr. RANSDELL. Or would this sediment drop in the river there and fill up?

Mr. COOLEY. No, sir; this is what will occur. In an alluvial river a steep or easy grade is purely a phenomenon of cross section. The tendency is toward a uniform velocity of 5½ to 6½ feet per second in high water. The cross section would shrink until the normal velocity was reached, and that would be the end of it.

Mr. HUMPHREYS. I do not understand what you mean by saying there is no flow in the lower Mississippi.

Mr. COOLEY. Not at low water—perhaps a foot per second.

Mr. HUMPHREYS. There is some, then? You said there was none.

Mr. COOLEY. There is some, of course; but the low-water velocity is nominal as compared with the high-water velocity. The tides show their effect up as far as the mouth of Red River in extreme low-water conditions.

Mr. RANSDELL. Now, coming to that dam again, or the effect of a dam which you spoke of as being created by the waters of the Gulf of Mexico meeting the waters of the Mississippi River. That does create a dam?

Mr. COOLEY. It does create a dam.

Mr. RANSDELL. On that point, when that dam is created there is a pretty considerable deposition of this sediment?

Mr. COOLEY. Yes; where it goes into the still water, absolutely.

Mr. RANSDELL. That makes a big sediment there?

Mr. COOLEY. Yes, sir.

Mr. RANSDELL. Why would it not make it above the dam?

Mr. COOLEY. It is because of the still water of the Gulf. Now, if you held that level that the Gulf holds, by means of a crest of a dam, and the water fell over it sheer, there would be no sediment deposited below the dam.

Mr. SPARKMAN. What would become of the sediment near the bottom?

Mr. COOLEY. That goes along just the same. Experiments have been made upon this matter. It is a popular idea that the bottom velocity is affected by a dam. Experiments have been made which simply verify what every engineer knows from his experience, that the bottom velocities hold unchanged up to within a limit of about two and one-half times the height of the dam. For instance, you have a dam that raises the water above the bottom 40 feet. The bottom velocities will hold up to within 100 feet of that dam.

Mr. SPARKMAN. What I was getting at is, would there not, by reason of that velocity below, be such an amount of still water as to cause the sediment to drop against the dam and fill up?

Mr. COOLEY. That angle may fill up above the dam.

Mr. SPARKMAN. And might that not gradually extend up the stream?

Mr. COOLEY. No, sir; if you study the profile of the bed of the Mississippi River you will find that it is a continual succession of pools and dams formed in nature.

Mr. SPARKMAN. It is a continuous succession of dams, I know.

Mr. COOLEY. Yes; and in high water every one of the pools excavates to levels of from 50 to 100 feet below the crest of the dam, the bottom is actually dug out, and also moved sidewise by bank erosion, and there is no trouble about that.

Mr. SPARKMAN. What is that water power worth there?

Mr. COOLEY. We estimate in the State of Illinois a revenue of $20 to $25 per horsepower. We usually estimate $20 per horsepower per year. Official estimates of the State make it $25 per year. In other words, 400,000 horsepower at $20 would produce $8,000,000 per year.

Mr. SPARKMAN. That is gross?

Mr. COOLEY. That is gross, from my standpoint. They figure it net. I am a little conservative on values. They can afford to spend in the State of Illinois $200 to produce a horsepower on the theory that it can be capitalized as a going concern at $400 a horsepower and will pay interest on that sum. Of course these estimates I have given for the river improvement do not include the cost of installation of the water power itself or the headworks and the flumes. You have to estimate for that expense when you develop the water power, and the market will justify the investment.

Mr. KENNEDY. Is there any demand for power down there?

Mr. COOLEY. Any demand?

Mr. KENNEDY. What cities are near it? Keokuk is going to furnish St. Louis with power, you see.

Mr. DAVIDSON. Keokuk may have a competitor.

Mr. COOLEY. You can sell all the horsepower you can produce. Industries will seek it.

Mr. DAVIDSON. You can carry it 200 miles?

Mr. COOLEY. The Keokuk proposition is to carry it 140 miles, out where coal is cheap.

The CHAIRMAN. We are carrying it to Syracuse, 150 miles.

Mr. RANSDELL. Do they not carry it 150 miles in California?

Mr. COOLEY. I think they carry it for a much longer distance in California. Coal is very costly there.

Mr. HUMPHREYS. There would be no question, I suppose, of a demand for 400,000 horsepower?

Mr. COOLEY. No, sir; they would put it to use as fast as you could produce it.

Mr. RANSDELL. They would build a city there.

Mr. COOLEY. I have been speaking only of what it is necessary to do in order to control these flood limits and produce 14 feet of water and produce it in such a way as to enable a progressive development hereafter up to a limit of 24 feet. There are incidental benefits which I have not mentioned. This scheme should contemplate ultimately the cutting off of Greenfield Bend opposite Cairo. The site of that bend would furnish an ideal harbor for that city, and would greatly help the situation, and simplify the lowering of the bed up to Commerce.

The CHAIRMAN. I did not catch what you were saying about Greenfield Bend.

Mr. COOLEY. Greenfield Bend behind Cairo has threatened the life of Cairo for a long time. The water runs across it at high water, and occasionally the reports call attention to the danger of its cutting off. I stated that if Greenfield Bend should cut off it would destroy Cairo Point.

The CHAIRMAN. I thought you were speaking of Greenville Bend, down in Mr. Humphreys's district.

Mr. COOLEY. No, sir; this is just opposite Cairo. You find it right here on the map [indicating].

The CHAIRMAN. I understand, but I thought you were referring to the Greenville Bend.

Mr. HUMPHREYS. Let me see if I understand your last statement. You think it is feasible to have it cut off?

Mr. COOLEY. Yes; in my judgment it is. You can cut off that 12 miles and shorten the river by 12 miles and put the slope that belongs to the bend up under your dam at Commerce and utilize it, and direct the cutting off in such a way as to avoid a menace to Cairo, and at the same time in the future the dead bend would become an ideal harbor site for the city of Cairo.

Mr. LAWRENCE. I understand your contention to be that by the construction of these two dams and the regulation of the river as suggested by you, you would create a 14-foot channel from the mouth of the Illinois River to Cairo?

Mr. COOLEY. Yes, sir.

Mr. LAWRENCE. And would develop 400,000 horsepower?

Mr. COOLEY. Yes.

Mr. LAWRENCE. What would be necessary to make that channel 24 feet?

Mr. COOLEY. Continue your regulation between the two dams; continue your regulation between Commerce and Cairo until those slopes in place of being 30 feet between the dams and 31 feet below the dam at Commerce as now, will be reduced to 15 feet, we will say, giving about 55 feet of head at each dam, and when you have approached some such result as that the 24 feet would be a consequence thereof. Above the dam at St. Louis it would be necessary to dredge from a point from about opposite the mouth of the Missouri up to the mouth of the Illinois, as we propose to do in the Illinois itself. That would be all that would be necessary.

Mr. SPARKMAN. Is it possible to determine the exact depth from any given amount of regulation work?

Mr. COOLEY. No, sir; I think not.

Mr. SPARKMAN. How did you figure on 14 feet, then, from the amount of work you propose to do there?

Mr. COOLEY. We figure the best way we can and trust that the Almighty agree with us.

Mr. SPARKMAN. Suppose He does not agree with you, what then?

Mr. COOLEY. We are up a tree. [Laughter.] But the experience in those matters is to a certain extent a guide. When you contract the river on the bar the same idea is involved in the movement of the water over that bar as in a tidal estuary or a tidal bar against the sea.

The area of a tidal opening is produced by the ebb and flow of the tide against the littoral drift which goes with the wave action along the shores, and always tends to close the opening, and it is the ebb tide which maintains the opening across the bar, and that opening will always be on the basis of a velocity in the ebb tide of 3 to 4 feet per second, depending on whether the beach material is fine or coarse, shingle, or something of that kind. There may come along a great storm which will choke the opening, and it will take a little time for nature to correct it. It is so with the river bar. Bars form in the Missouri and in the Mississippi in high water, and as the water falls channels are cut through the bars, and the cutting continues until the velocity is reduced to 3 or 4 feet a second. Occasionally this action fails. There is a phenomenon in bar formation like what occurs in the miner's sluice. The material under a heavy current will sometimes arrange itself in a curious manner. I have seen currents of 6 or 7 miles an hour over a bar, running like a mill race, and the bottom as hard as this floor when you tried it with an oar, but with any little disturbance that might initiate a movement in that bar, it would sweep it out in a week. Some of these things may temporarily interfere, but as long as the forces are there, you may be absolutely sure that sooner or later there will be a proper response.

The CHAIRMAN. It is a fact that the 14-foot waterway board did not expect to do anything more to the river than to get a 9-foot channel, and then when these bars formed, if they did form, they would be removed by the dredge, and the additional expenditure, the increased expenditure, on a 14-foot over a 9-foot depth was entirely for dredging?

Mr. COOLEY. Yes, sir; that was on the $21,000,000 project between St. Louis and Cairo.

The CHAIRMAN. Yes; I am speaking of all the way down. That was below Cairo.

Mr. COOLEY. That was their project—is their project—that when these banks are revetted and made permanent, as we expect they will be, you will probably get 14 feet. Possibly bars may form through defective work or other cause, which must be corrected by dredging.

The CHAIRMAN. Yes.

Mr. COOLEY. That is the theory, below Cairo, that the dredging would not be required except in some contingency.

The CHAIRMAN. That is right.

Mr. COOLEY. Or from some abnormal cause.

The CHAIRMAN. Yes.

Mr. COOLEY. But between Cairo and St. Louis it is not the theory, as I understand the report.

The CHAIRMAN. Yes; there is the same there, is there not?

Mr. COOLEY. They have proposed a dredge fleet there to cost $3,600,000, and $1,500,000 annually for operation, and I do not know that they assume, but I gather from the report that they do, that the regulation for 8 feet will produce more.

The CHAIRMAN. I think the expectation is that it will; but the dredging will put it down to 14 feet. That is a sort of an auxiliary to the work of the river itself.

Mr. COOLEY. They did submit two alternative plans to make a permanent 14 feet, which I discussed while you were absent.

The CHAIRMAN. I would have been very glad to have heard that, but I was obliged to leave you for a few minutes to see Judge Taylor, of the Mississippi River Commission, who expected to be present to-day and take part in the discussion, but who was obliged to take an early train to leave town.

Mr. COOLEY. I would have been very glad to have heard Judge Taylor, because I think he is one of the clearest-headed men on this subject that I know.

Now, following up the project further, you produce the 55 feet of fall at the dams; I do not state that as the actual result, but for illustration. It will be somewhere in that vicinity; it may be more or less. Assuming that in the progress of conservation you are going to increase the flow of the upper Mississippi by reservoirs, and the flow in the Missouri and perhaps also in the Tennessee—which would not affect this project we are discussing—I assume there is in sight a possible flow of 80,000 feet per second instead of 55,000 feet, in the not remote future. Such a volume of water under such head would double the power at each of these dams, and of course make the regulation for large depths easier.

Mr. MADDEN. I do not know whether it is convenient for you to do so now, but will you, when it is so, tell the committee along conservation lines what effect it will have on the Lake levels?

Mr. COOLEY. Yes; that question was raised this forenoon and I intend to go into it later, if desired. The whole proposition, as it looks to me, is that we can and should lay out this project for an ultimate 24 feet, that we can do so without any extraordinary increase in cost, and that if we do do so what depth we obtain is not so material at the outset, provided we put ourselves in a position for progressive development for the needs of the future. I am not enough of an egotist—I hope nobody else is—to set up my mental limitations and conceptions as a measure of what the future is going to do or requir . I know in 1889 I drew the joint resolution for 14 feet through the Illinois Valley. I did that in view of the physical situation which existed there, from which it seemed to me impossible to tolerate any improvement of a less depth. I had no data to justify me on the cost of doing that work, within reason, except the experience of the city of Montreal in dredging ship channel through Lake St. Peter, in the St. Lawrence, material of somewhat similar character, done at that time at a cost of about 10 cents a yard. Since that time there have been resources in engineering art that have revolutionized the possibilities, and one of them is the hydraulic dredge. You can not sit down and figure out the cost of hydraulic dredging, if you have enough of it to employ your machines, at more than 3 cents a yard; but call it 5 cents. The other resource of which I speak is the art of concrete masonry. Masonry that formerly cost $18 to $24 a yard for dams and locks and other structures is now produced for from $5 to $7 a yard, and is better suited to the purposes. At that time locks of 10 to 15 feet lift were employed and 20 feet was abnormal. The Soo lock was regarded as an extreme. Since then lock designs have reached 40 to 50 feet. I prepared the report of the International Commission of 1897 and I took the position that our engineering resources justified hydraulic locks of 50 feet.

The CHAIRMAN. If you have a lock 30 feet high, and it would cost $4,000,000, would one 60 feet high cost $8,000,000?

Mr. COOLEY. No, sir.

The CHAIRMAN. It gets cheaper as it gets higher?

Mr. COOLEY. No, sir; but when you speak of a lock of 30 feet lift, you may have 20 feet depth in the channel and the lock wall may be 55 or 60 feet high, and if you add 30 feet to the height of the lock wall for double lift you are not doubling the quantity of the material in the lock.

The CHAIRMAN. Then it would not cost as much to build five locks giving 140 feet of fall as it would nine locks giving the same fall?

Mr. COOLEY. No, sir; other things being on the same scale of magnitude. No, sir; it would not. I put the proposition for locks of 50 feet lift in the report of 1897, with this modification. The two Canadian engineers on the commission, Mr. Munro and Mr. Kieffer, who were then perhaps the best authorities on this side of the Atlantic on lock construction, said that if I would make that 40 feet they would concur in it, and it was so adopted. It was about double the height of any lock then built in the United States. Since that time we have had designs of 50 feet for the Georgian Bay and St. Lawrence routes, and also for the Hudson River route. A series of combined locks was proposed down the Niagara escarpment in gates would be subject to a pressure of nearly 80 feet of water at times, and this is greater than anything that I have had the nerve to propose. I have not gone over 65 feet on that proposition. Up to that height lock designs are within economic limits. I worked out the locks for 110 feet lift at each end of the Niagara project. I do not remember whether you have two locks or three at Panama, covering 85 to 95 feet.

Mr. MADDEN. Three for 95 feet.

Mr. COOLEY. On the barge canal in New York I know they have some projected at 37½ feet. I do not know whether any higher locks have been actually built.

As I was saying, with the probable conservation of the future and the increase of flow that would become available and with the regulation for 24 feet, there would be about 400,000 horsepower at each of these dams.

Mr. MADDEN. Instead of $200,000?

Mr. COOLEY. Yes. In other words, you would have an aggregate of 800,000 horsepower. I will not dwell upon that. The advantages are obvious, not only in the possibilities which it brings, but in the commercial utility of the water power itself and in the situation which it creates at St. Louis for harbor purposes, the possible situation for the future at Cairo, and in backing the water up the Mississippi and the Missouri, thus contributing to a certain extent to the future improvement of those streams. I want to call your attention to this fact, that in such an ultimate scheme, out of a total fall of 306 feet between Lake Michigan and Cairo 243 feet can be taken up by dams, leaving 63 feet to propel the river. In other words, 80 per cent of all the fall between those limits can be converted into commercial power, and I hope that some way can be devised to bring this to pass.

From my standpoint, all our streams and lakes should be treated on the basis of the fullest possibilities of conservation of our water resources, and you can just as well have it this way as in any other.

I think one of the gentlemen of the committee asked me something about lake levels.

The CHAIRMAN. That was Mr. Cassidy, and he asked me to explain to you that he could not come here this afternoon because he had made an engagement, supposing that our meeting would end at half past 1. He regretted exceedingly that he could not be here.

Mr. YOUNG. We would all like to hear about the lake-level proposition.

Mr. COOLEY. If you desire me to go into that, I will now take it up.

The CHAIRMAN. We certainly do.

Mr. COOLEY. Before I projected the Chicago Sanitary Canal in 1885, I went into this question because it was one of the obvious things for investigation. Before we passed the sanitary district law in the State of Illinois in 1889, the matter was examined exhaustively with all the data that were then available, and there was printed a full discussion of the matter by the Western Society of Engineers in 1889, by several leading experts who were specially competent to form a judgment in such matters. The result of those investigations was to indicate that 10,000 feet of water per second would lower permanently Lake Huron and Lake Michigan by 3 to 5 inches. The data were not sufficiently positive to indicate the definite measure, but the lowering of Lake Erie would be somewhat less, and the effect would diminish down the St. Lawrence. There were no adequate data or measurements made by up-to-date methods until after the report of the International Commission in 1897. Between 1897 and 1901 the Deep Water Board made a series of measurements, and these have been supplemented by the International Commission on Lake Levels. I have not critically examined the later data, but the report of the commission in 1906 on the Chicago Drainage Canal states that the effect of diverting 20,000 cubic feet of water from Lake Michigan would be to lower Lakes Michigan and Huron by 1 foot, and by a lesser amount in Lake Erie, and decreasing down the

St. Lawrence. The statement amounts to this, that the outlet of Lakes Huron and Michigan, the St. Clair River, at a stage 1 foot lower, will carry a volume 20,000 feet less, and in some other ratio for the outlets farther down. Therefore the effect is deduced that the diversion of 10,000 feet of water will lower Lakes Michigan and Huron by half a foot, or 6 inches, and of 14,000 feet by seven-tenths of a foot. I do not think anybody responsible for the Chicago Drainage Canal, certainly not myself, has ever been disposed in any manner whatever to deny or mitigate the effect on lake levels. I think, however, from my former investigation, that the board does not understate the amount of lowering, but whether it be half a foot for 10,000 feet and seven-tenths of a foot for 14,000 feet, or whether it be more, is not necessarily material from my standpoint. I have always assumed that at the proper time and when the matter became material, it would be necessary to make some provision in the premises, and there are a variety of ways in which this matter can be treated. I will mention one or two of them. Take Lake Superior. It has an area of about 32,000 square miles. The other lakes—Erie, Huron, and Michigan—have an area of about 56,000 square miles. A foot of water on Lake Superior is equivalent to seven-tenths of a foot on the Lakes below, and whatever amount is necessary can be held back and released on the low-water stages. The cost of doing that, independent of any change in the regimen of Lake Superior, would be in effect the cost of a franked envelope from the office of the Secretary of War addressed to the engineer officer in charge directing him to regulate the flow at the Soo.

Mr. KENNEDY. What is that?

Mr. COOLEY. I said that the cost of using Lake Superior as a reservoir and turning its volume in at the low-water stage in Lakes Huron, Michigan, and Erie, would be the cost of a franked envelope from the War Department to the engineer officer at the Soo, directing him to regulate the flow through the dams and sluices at that point, which have been put in for water-power purposes.

Mr. MADDEN. In other words, all that would be necessary to be done would be to give the order?

Mr. COOLEY. Yes, sir.

Mr. YOUNG. How rapidly could that surplus water that has been impounded up there be forced through the St. Marys River?

Mr. COOLEY. Sufficiently rapid for this purpose.

Mr. YOUNG. How rapidly, in addition to the natural flow there is now?

Mr. COOLEY. I have not figured that out closely; but suppose you reached a stage at which you wanted to arrest the further effect of the Chicago Drainage Canal, you would release the 14,000 additional feet of water through the St. Marys River from Lake Superior that the Chicago Drainage Canal is taking out. Any further lowering is then due to natural causes.

Mr. YOUNG. But would that water that would pour through there in that way be distributed over Lakes Michigan and Huron immediately and evenly?

Mr. COOLEY. Sure; automatically. It is practically an infinite expanse, so far as the flow of water is concerned. It is just like a tub. You put a pint of water in a tub of water and it raises the level of the whole surface immediately. It would raise the level as fast as the waves of translation could mobilize.

The CHAIRMAN. To secure that water from Lake Superior you would have to have a dam to add to that?

Mr. COOLEY. I do not know whether the dam is completed or not, but a statute was passed, and I took the trouble to come to the hearing—the hearing was before this committee—granting certain rights to the Soo Water Power Company, and it was required to operate the dam under the direction of the Secretary of War.

Mr. DAVIDSON. The controlling works they were to construct in the river were to compensate for the amount they took through their canals above the navigation canal, for power purposes?

Mr. COOLEY. Yes.

Mr. DAVIDSON. But those controlling works were not intended to add to the storage of Lake Superior, were they, in any way?

Mr. COOLEY. They could be used for that purpose.

Mr. DAVIDSON. By prohibiting them from using their power canal?

Mr. COOLEY. No; they are using only a portion of the flow. It is simply not necessary to materially change the level of Lake Superior; the increment, which now reaches its maximum in August, is simply to be deferred—that large, high water—until later in the season, when it will be released on the low water below.

Mr. DAVIDSON. But that has got to be by a dam which stores it above its natural level?

Mr. COOLEY. Yes, sir.

Mr. DAVIDSON. Now, these controlling works only hold a certain amount from going over the rapids, but it all goes into the St. Marys River again?

Mr. COOLEY. Yes.

Mr. DAVIDSON. Any discharge that might be regulated by the dam would presuppose a dam sufficient to hold the water up and furnish a supply to be released through the low-water stage?

Mr. COOLEY. Lake Superior fluctuates over a range of 3 to 4 feet (3.44 feet in thirty-six years and 1.2 feet annually), and you have only to use part of that. A depth of 3 inches represents 14,000 feet for six months, and this is sufficient to compensate for the draft at Chicago in the low-water half of the year.

Mr. YOUNG. During how long a period is there such a fluctuation of 3 or 4 feet?

Mr. COOLEY. It goes through a long period; that is the record for thirty-six years.

Mr. YOUNG. It is a good many years, is it not, since there has been as much fluctuation as that? Is it not about fourteen years?

Mr. COOLEY. That I do not recall at this time. I compiled all those data at one time.

Mr. DAVIDSON. Is it not a fact that the lake is lower than it has been and that all the lakes are lower for a cycle of years than they were before?

Mr. COOLEY. No, sir. The lakes below Superior have been rising since 1895. A complete record of the lakes, all that was obtainable in the United States and Canada, was compiled under my direction in 1896 and published in the report of the international commission in 1897, and in that report we have data running back to the low water of 1819, authentic data as to all the lakes except Lake Superior. We have little data of Lake Superior back of 1864. The low water of 1819 was a long-continued low water in all the lakes from Michigan down to Ontario—Michigan, Huron, Erie, and Ontario—and was 8 inches lower in Lake Michigan than any low water we have had since. It was 8 inches lower than the low water of 1895, which was the lowest water that has obtained in the lakes since 1819. The extreme range between those two waters on Lake Michigan was 6 feet 5 inches. Now the ordinary annual fluctuations are within limits of a couple of feet, but in a series of years we have these extreme ranges.

Mr. YOUNG. While you were impounding this water on Lake Superior and raising and collecting your extra foot there, which would naturally fall down the St. Marys River into Lake Huron, what effect would that have, if any, on the levels of Lakes Huron and Michigan?

Mr. COOLEY. Lakes Michigan and Huron would not rise as high in the months of June, July, and August by the amount that was stored on Lake Superior.

Mr. YOUNG. What time do you expect to make that collection on Lake Superior?

Mr. COOLEY. I would make it at the time of the year when the water begins to rise on Lake Superior, allowing to escape from Lake Superior at all times the minimum flow.

Mr. YOUNG. What months would those be?

Mr. COOLEY. Ordinarily they would be June, July, and August. After that there is no rise in Lake Superior, no accession in water beyond what comes out of it.

Mr. SPARKMAN. How would you prevent, then, the low water in Lakes Michigan and Huron? You say there would be a difference of a foot. How would you prevent that, if you wanted to prevent it?

Mr. COOLEY. We would not want to do it. That is the time of high water in the lower lakes, and a lowering of the high water is not important. Our lakes fluctuate just as a river does, and we do not use the flood flow.

Mr. SPARKMAN. Do I understand you to say that turning loose a given quantity of water in the upper portion of Lake Huron, for instance, it would be felt immediately in the lower end of the lake?

Mr. COOLEY. Yes sir; for all practical purposes, immediately.

Mr. SPARKMAN. And also in the lower end of Lake Erie?

Mr. COOLEY. No sir; not so quickly, because there it is a case of constrained flow through the intermediate rivers.

Mr. SPARKMAN. How long would it take to get down there?

Mr. COOLEY. If you started it early enough it would simply arrest the fall of the Lakes.

Mr. SPARKMAN. I understand that, but how long would that be?

Mr. COOLEY. That would be immediate, so far as Lakes Michigan and Huron are concerned.

Mr. SPARKMAN. I am speaking of Lake Erie, now.

Mr. COOLEY. It would lag a little; I do not know how much. I have not gone into that in detail. I am not presenting this as a recommendation, I am simply stating it as one of the suggestions. There are other methods.

The CHAIRMAN. You know, of course, that the International Waterways Commission has recently turned down a proposition of regulating works at the head of the Niagara River at Buffalo?

Mr. COOLEY. I did not know that.

The CHAIRMAN. They have done so very recently, because they have been obliged to admit, after long engineering study, that it would, by putting the regulating works there, lower the water in Lake Ontario and in the canals of the St. Lawrence; that no dam could be put there to hold the waters back without lowering the waters in the St. Lawrence canals so that it would make them unnavigable, almost, and the Canadian officials have declined; and I see that our American commissioners on that commission have agreed to their statement, that that is the effect that it would have. If you attempt to impound the waters in Lake Erie by such a dam as you speak of there in Lake Superior, it will decrease the depth in Ontario and materially so, of course, in those canals along the St. Lawrence. The hope that I have had is that there might be regulating works put across the head of the Niagara River holding the water back at least a foot when necessary.

Mr. COOLEY. Yes.

The CHAIRMAN. And it was suggested that it could be so arranged that in the high water it would flow right over.

Mr. COOLEY. Yes.

The CHAIRMAN. But it seems other people take a very different idea from that and have practically put out of consideration any immediate construction, at least, of regulating works at Niagara.

Mr. COOLEY. I have not seen the last report on this proposition. I will speak to that in a moment, because it was a matter I gave some consideration to when I was on the first international commission.

In regard to the Lake Superior reservoir there has been a great deal of difference of opinion. My own view, however, has not been shaken. You can control and equalize the flows in the lower lakes by reservoirs the same as in a river. Nature has no distinct law or different law for the two cases. The lakes are simply an expanded stream, however you may figure it, up or down; if it is possible to equalize the flow of a stream, then it is possible by a reservoir like Lake Superior to equalize in some degree the levels and flow below. I say it is an absolute principle; you can not get away from it.

The CHAIRMAN. Of course those reservoirs at the head of the Mississippi have been an utter failure, 30 or 40 miles below St. Paul, in keeping up the depth of the river. Mr. Stevens tells me they do give a little additional depth for the first 40 miles below St. Paul, but nothing beyond that, and as you know, the question was for years seriously debated as to whether we should not abandon the reservoirs at the headwaters of the Mississippi; but because of the additional depth they gave for 30 or 40 miles below St. Paul it was thought best to repair and maintain them, and so we did.

Mr. COOLEY. It is a pretty large subject, Mr. Chairman, to go into unless we have an adjourned session. I hold pretty strong views on the conservation of waters and the utility of reservoirs; I have examined the Fox and the Rock rivers in Illinois and Wisconsin particularly, and I believe it is feasible in a majority of the tributaries of the upper Mississippi to double and treble their low-water flow, making the minimum continuously that much larger. I have never taken the view that you can build storage reservoirs at remote headwaters and then release the water to meet conditions several hundred miles below; but you can increase the minimum flow in the stream itself, and the aggregate effect of such treatment will be profound on the main rivers. The matter is habitually discussed on the theory of a remote reservoir like that at Pokegama, so operated as to produce a specific effect far below, and the result is disappointing.

Mr. HUMPHREYS. What has been the effect of the dam at Assouan?

Mr. COOLEY. That I do not understand has the motive of a storage dam, per se.

Mr. HUMPHREYS. That was not the purpose of it?

Mr. COOLEY. Although it did have some storage, but not large as compared with the entire flow of the Nile. Its primary object was to raise the level of the Nile so as to feed high-level canals and thus reach a larger area for irrigation; that is the way I understand it; or to raise the horizon of the river; and in that respect it has been effective.

Mr. HUMPHREYS. It has been effective?

Mr. COOLEY. Yes. Now, in regard to the dam at Black Rock spoken of by the Chairman, I have not seen the report or the argument made by the commission.

The CHAIRMAN. I have not seen it excepting that it has been stated in the Buffalo papers, and perhaps in dispatches through the country.

Mr. COOLEY. I do not think, as it appears on its face, that I could concur in that statement at all. I did make estimates for the raising of the level of Lake Erie by something over 2 feet. I did find the backwater effects would extend up the Detroit and St. Claire rivers to the head of the St. Claire Delta. The Board of Engineers on Deep Waterways (Report, 1900) did propose to build a dam there that would raise the level of Lake Erie by 3 feet, and they did figure out the effect thereof to be the raising of Lakes Huron and Michigan by 1 foot. I did not have the later data, but my results indicate that a dam of the height proposed would at least restrain the lowering of Lake Huron. From personal conversation with members of this last international commission, I infer that they accept the report of the Board of Engineers on Deep Waterways as to the effect of this dam.

Then there is a further proposition to which the board of which I was a member called attention, and to which I believe the later boards have also called attention, that when we undertake further enlargement and deepening of the intermediate channels of the Lakes we will profoundly affect the levels themselves. There is no question in my mind but that the improvements already made have materially affected the levels.

The Deep Water Board (Report, 1900) determines a lowering of about 1 foot (0.9 foot) for Lakes Michigan and Huron, through the cutting out of the bar and the enlargement of the channel at the head of the Port Huron Rapids of the St. Claire River, between 1886 and 1890. The board regards this change as permanent and as due to or initiated by the improvements which have been made in the channel between Lake Huron and Lake Erie. I am not prepared to say that this change is a permanent one, but it may have been initiated much as a hydraulic dredge initiates a channel across a Mississippi River bar, through which the water rushes to enlarge and deepen the same.

The CHAIRMAN. What was the depth of the St. Claire River?

Mr. COOLEY. The St. Claire flats had an original depth of about 10 feet. The original canal was built for 13 feet.

Mr. EDWARDS. What is the depth?

Mr. COOLEY. Twenty or 21 feet, they call it.

The CHAIRMAN. It is natural to suppose that it would deepen the outlet, with the larger volume of water that goes through it, which requires more opportunity to escape.

Mr. COOLEY. Yes. The point I wish to make is this: With this new Soo lock and the larger boats we are going to have—working up to a draft of 24½ feet—and larger channels, more ample in width and depth, and with the possibility, which, to my mind, is not remote, that the Great Lakes will in effect be made an arm of the sea both ways, east and south, you absolutely must control the levels of the Lakes, and you must slack-water the St. Lawrence all the way to the sea. Now, it is as easy to control the level of Lake Ontario as it is to control the level of Lake Erie. I have made some studies on that subject.

Then I want to make another suggestion to you. The flow of water which we are taking out at Chicago, or rather the flow which we have provided the capacity to take out, of 14,000 feet per second, is between 6 and 7 per cent of the average flow down the Niagara River, which may be taken at 231,000 second-feet. The latest determinations give 220,000 feet per second, and it ranges from 275,000 at high lake to 175,000 at low lake. I do not refer to abnormal effects due to storms, but the flow due to the natural levels of Lake Erie. All works and all uses of water have been based on low-water volume and conditions, and in all times flood volumes in excess of what can be utilized have been regarded as a public nuisance, to be protected from in the best way possible. Everything that is useful down the St. Lawrence for water power, navigation, or any other purpose is represented in the minimum flow, not the extreme minimum but the ordinary low-water flow, say 180,000 feet per second in the Niagara River. There can be no harm and there will be great benefits in treating the Great Lakes as storage reservoirs and giving the St. Lawrence this ordinary low-water flow of 180,000 feet and turning the surplus 40,000 feet down the other way and putting it to use. Now, I want to put that proposition up to you squarely. You have a natural reservoir here of 88,000 square miles. You have propositions all over this country to store water, and nobody has thought to put into use 88,000 square miles of reservoir that you already have and utilize this water, and there is no legal reason, or reason of any kind—there certainly is none in engineering—why you can not do it. You should do it—utilize your natural resources before constructing artificial ones at enormous expense.

Again, there are thousands of square miles of territory adjacent to the watershed of the Great Lakes, from which the surplus waters can be diverted into the Great Lakes, thus greatly increasing the amount of storage, and this can also be turned to a useful purpose. This is another way to remedy any deficiency in lake volume.

Mr. MADDEN. Then your contention is that no real detriment to the lake levels would occur if the Chicago deep-waterway proposition took 50,000 cubic feet of water per second instead of 10,000 or 15,000 feet?

Mr. COOLEY. If they do what they must do, in my opinion, if they are to get deeper water between the Lakes for purposes of navigation, 24½ feet for the new Soo Lock and the 30 feet estimated for ocean navigation, they must control the levels. A very moderate expense will prepare the Lakes for the storage that is necessary to turn 40,000 feet the other way and rob nobody.

Mr. MADDEN. What is the difference in the levels of Lake Huron and Lake Michigan?

Mr. COOLEY. None.

Mr. MADDEN. Is there not any?

Mr. COOLEY. Absolutely none.

Mr. MADDEN. What is the difference of the level of Superior?

Mr. COOLEY. About twenty feet; (20.43 mean stage) and Lake Erie is 8.4 feet lower at mean stage.

Mr. MADDEN. Is there any current there?

Mr. COOLEY. Both ways. There are conditions where Huron stands above Lake Michigan, and then again where Lake Michigan stands above Huron. The records made up show that for a portion of the year the elevation of Huron is slightly above that for Michigan, and for the other part of the year it is slightly lower.

Mr. TAYLOR. What is the difference in size between those lakes?

Mr. COOLEY. Lake Superior has about 32,000 square miles; Lake Huron about 23,000; Lake Michigan about 22,000; Lake St. Claire 500; and Lake Erie about 10,000; the total being 88,000 square miles, as I remember.

Mr. TAYLOR. There are four lakes, and the total area is 88,000 square miles, of which Superior has 32,000 square miles?

Mr. COOLEY. Yes.

Mr. TAYLOR. What is the rainfall on the different lakes? Is there any difference in that?

Mr. COOLEY. Yes. The average rainfall for all the lakes is about 32 inches; 28 inches on Lake Superior and 36 inches on Lake Erie, and 32 to 33 inches on lakes Huron and Michigan. The annual run-off is about one foot in depth and amounts to seven-eighths of a foot per second per square mile. That is what reaches the outlet of the entire basin of 264,000 square miles, including the lake surface, which drains into the lakes above Niagara Falls.

Gentlemen, if the committee is not exhausted, the speaker is very nearly so.

Mr. HUMPHREYS. Have you finished on the subject of lake levels?

Mr. COOLEY. Yes, sir.

Mr. HUMPHREYS. You spoke of this 24-foot project on the Mississippi?

Mr. COOLEY. Yes.

Mr. HUMPHREYS. And you said that it did not make any difference what depth you started with, if you had that depth of 24 feet in ultimate view?

Mr. COOLEY. Yes.

Mr. HUMPHREYS. What did you mean by that?

Mr. COOLEY. I meant this, that as long as you laid out your work for an ultimate depth of 24 feet with these large locks, which should be 110 feet by 1,000 feet, which I believe ought to be the scale of development, the development of the channels themselves, except in the particular to which I have called attention in connection with the dam at St. Louis, is a progressive matter, when you do not have to tear out works and rebuild; the depths obtained can be progressive. While you may really get less than 14 feet at the outset, the 14 feet is coming, and by and by you are getting more, and that is an incident of the matter. It is not something to be constructed like a building, but a progressive or evolutionary proposition.

There is one thing that has been spoken of here that perhaps I did not answer fully, and that is in regard to the size of the locks.

I think I gave one answer to it. The width of 110 feet has become a kind of a standard. It is adopted for the Ohio River and for the Panama Canal, and the length of 1,000 feet has been adopted at Panama. I believe that these locks should be made as great in their dimensions horizontally as any on earth. We actually have a type of boat that to my mind will be much used on this route, with a width of more than 100 feet over all. We will expect a high development of barge movement, and there is the same justification for a wide and long lock in this case as you have in the case of the Ohio River. There is a point, however, on which I hoped to be able to speak absolutely by authority, but can only do so partially, and that is in regard to the shipbuilding industries of the Lakes. I had complete information upon this question a few years ago, but I do not know the present position of the shipyard interests, except in one instance. My information is that we can build on the Lakes to-day ships for the world, and sell them in competition with any country, if we can get them out to the sea. Fourteen feet will enable us to do that on anything from a battle ship up to a liner, or any other craft that can pass the locks.

Mr. RANSDELL. Fourteen feet, you say?

Mr. COOLEY. Yes, sir.

Mr. RANSDELL. Our big battle ships can be floated out on 14 feet?

Mr. COOLEY. Yes.

Mr. RANSDELL. How nearly completely constructed would they be?

Mr. COOLEY. They would not have their armament or armor on. Those would have to be put on down at New Orleans, or in deep water.

Mr. YOUNG. Why could those ships be constructed more cheaply on the Lakes than on the Atlantic?

Mr. COOLEY. Because the materials to construct them on the Atlantic and in Europe come from the Lake region.

The CHAIRMAN. What kind of material?

Mr. COOLEY. Iron, ship plates.

The CHAIRMAN. You propose to carry the material down by barge and put it on down at the sea?

Mr. COOLEY. Yes, the armor and armament; but the hull, and other vessels that can float light on 14 feet, can come down through the locks.

Mr. YOUNG. There has been very little iron made at the Lakes for any kind of armor or armament.

Mr. MADDEN. We have now on the Lakes, near Chicago, the biggest steel plant in the world.

Mr. COOLEY. Gary; yes.

Mr. MADDEN. At which could be constructed any kind of steel or iron work that might be required?

Mr. COOLEY. Yes; and a large plant is projected on the shores of Lake Erie. I do not know that; I was told that the other day. I remember very distinctly when the Lake Erie and Pittsburg Ship Canal was being promoted, it was said at the time, and I believe it is true from my investigations, that it would cheapen the cost of pig iron in this country by 20 per cent and put us beyond the possibility of world competition. The Cleveland Chamber of Commerce employed experts to show that the cheapest location for manufacturing iron and steel was on the shores of Lake Erie.

The development on the Lake Michigan shore at Gary and projected on the Lake Erie shore indicate a new order of things.

Mr. HUMPHREYS. I did not understand what you said as to the proposition that a vessel can be constructed more cheaply on the shores of the Lakes than elsewhere.

Mr. COOLEY. The material is produced there. The ore of Lake Superior is ferried down the Lakes, and can meet at the shore the coke from the Connellsville region and the high-grade coal, and these are the materials that go to make iron.

Mr. HUMPHREYS. I understood you to say the difference was in the cost of plates.

Mr. COOLEY. Yes; it is in the cost of plates.

Mr. HUMPHREYS. What percentage of the cost of the battle ship is in the cost of plates?

Mr. COOLEY. That I do not know. I do not know how the hull and armament and armor are divided—in what ratio. The argument has been made that lake vessels could not go to sea. I think that is so stated in one of the official reports. Mr. McDougall told me the other day that he had three vessels at sea now, one of which had gone around the Horn, and all of which had been built on the Lakes.

Mr. HUMPHREYS. Who is Mr. McDougall?

Mr. COOLEY. Mr. Alexander McDougall, who owned a shipyard at Duluth and built the whaleback boats. He said further that lake boats were built on sea dimensions for strength, and that modern lake vessels could go to sea; and he said also that they could be built for $40 per ton. I believe $70 has been given in the report. I did not intend to go into this subject except by way of suggestion, because the figures I am trying to state are very important, the relation of the shipbuilding industry to this route is extremely important, and I expected to be able to submit exact figures from the authorities themselves, based on the opening up of this route, but, unfortunately, I have not been able to prepare myself fully before the committee came up to this matter.

There is only one more thing I wish to say, and not by way of information. When the first International Commission was appointed in 1895, with instructions to consider the possibility of extending ocean navigation to the head of the Great Lakes at Chicago and Duluth, Mr. Cleveland desired to appoint Senator Edmunds. Senator Edmunds had retired from public life in order to earn a little surplus in his declining years. He referred to this in the letter of declination, and, among other things, stated "that he had been in public life from the time when he attended on his duties in a stage coach to the time when he rode in a Pullman car, and that for fifty years he had voted for public works that had become obsolete before they could be completed. The project before this commission was fraught with more possibilities for the future of the country than anything he could think of, and he hoped that the commission would work out the project on such a scale of magnitude that no one for one hundred years could wish that it had been made larger."

With this as my benediction, gentlemen, the matter is up to you.

The CHAIRMAN. We are very glad to have heard from you. It has been a useful and a helpful day to us.

(Thereupon, at 5 o'clock p. m., the committee adjourned.)

O